Friday, 17 June 2016
(09.45 am)
PROFESSOR GERALDINE THOMAS (continued)
MR HEPPINSTALL: My Lord, just before Dr Busby resumes, I hope that SB22 has reached your table. I sent three up this morning. Ah, they are in the racks.
MR JUSTICE BLAKE: Oh, right, I see. Yes, very good.
MR HEPPINSTALL: I am very grateful to Hogan Lovells for providing the index. We've put some material in there and then it occurred to us that you may have marked your own copies.
MR JUSTICE BLAKE: Well, I might have done but I can substitute.
MR HEPPINSTALL: If you are missing anything, then please let us know.
MR JUSTICE BLAKE: I will try and do that in the course of this morning. (Pause)
Where are we going to put the materials which we've been provided by Dr Busby overnight?
MR HEPPINSTALL: I going to put them behind the relevant abstracts.
MR JUSTICE BLAKE: Abstracts. Righty ho.
MR HEPPINSTALL: I think their location is noted upon them, as I understand it. (Pause)
MR JUSTICE BLAKE: We'll do that. We won't put them into

the generic 22.
Good, thank you very much. Yes.
Cross-examination by DR BUSBY (continued)
DR BUSBY: Good morning, Professor Thomas.
A. Good morning.
Q. It might help if I just outline where I think we've got to and then we can continue from there.
Because of the problem that you had with the abstract of the paper on uranium we had to break off from the uranium issue and so then we moved to the issue of thyroid cancer --
MR JUSTICE BLAKE: Your voice is a bit low. Can you pick it up a little bit?
DR BUSBY: I'm sorry. So we then turned to the question of thyroid cancer in Chernobyl, in the Chernobyl affected areas.
A. Yes.
Q. Now, you agreed with me that there was a significant rise in the incidence of thyroid cancer in the areas affected by Chernobyl?
A. In those who were children at the time of the accident, yes.
Q. And we agreed, I thought you said, that the accepted mean dose was 500 millisieverts?
A. For evacuees.

Q. For evacuees. But presumably for people who were outside the exclusion zone, that dose would have been less?
A. Yes, considerably less.
Q. Well, would it have been -- I mean, can you give some sort of idea of how much less?
A. If you look in the UNSCEAR report of 2008 I'm sure you'll find in the tables there a full table of various doses, various ages, because it varies on the ages of the children and the various areas and that will give you all the information that you want.
Q. Can you tell us approximately what the increase was numerically?
A. To date, it's around about 6,000 thyroid cancers that are in excess of what we would expect in that population.
Q. So what would that be as an excess fraction? For instance, was it twice or five times?
A. No, it's considerably higher than that and it varies depending on the area. It's impossible to give you precise details unless the question is precise enough I'm afraid.
Q. You could say it's not more than 20 times?
A. In some areas it's not. In some areas it's barely raised, in other areas where the dose was higher -- it

is related to dose. In those areas where the dose was highest, which is basically the Gomel area of Belarus, it's about 100 fold in some age groups. But again, it's not a simple equation. You have to bear in mind that the susceptibility is different at different ages of exposure, different lengths of time studying afterwards, and we're not through the end of it yet. So it's important to bear those caveats in mind.
Q. What I am sort of trying to get to is what would have been predicted in that population on the basis of the ICRP risk model?
A. Sorry, I can't comment on that because it's such a variation. It depends on what dose people had.
Q. Well, I think what I am trying to --
A. I can tell you what is predicted overall, based on Elisabeth Cardis' predictions, which is up to 2050 about 16,000 excess thyroid cancers in those areas. Now she will have used the ICRP risk model.
Q. So what would have been the background rate over that period of time? This a very rare cancer.
A. The background rate in children aged under 14 varies between 0.5 per million per year to 1.5 per million per year across the globe. It's probably in that area, around about 1, because it is moderately iodine deficient.

Q. Do you know what the population of Belarus is?
A. Not offhand, no.
Q. Would you disagree if I said it was 3 million?
A. Probably. That's probably about right. I would think it was nearer 6, actually, but I could be wrong, and of course there's been considerable migration from Belarus since the accident so it depends on when you are asking when that population was there.
Q. As one might expect, I guess, but you just said that the risk -- that the background rate was less than 1 per million.
A. No, I said it varies. It was probably about 1 per million per year.
Q. So in a population of 3 million you would expect 3 cancers per year?
A. Yes, but that's not children. The population is not 3 million children.
Q. No, of course not, but it includes children?
A. Yes.
Q. If we take the number of children -- and I think you called children 0 to 18?
A. 0 to under 14 is the accepted conventional age at which you cease to be a child internationally.
Q. Okay, so --
MR JUSTICE BLAKE: For scientific purposes. Not for the

conventional --
A. Not for law purposes, but for scientific purposes. Most of the childhood cancer registers stop at 14, my Lord.
DR BUSBY: So in a population of 3 million, assuming the population is even square, that is to say that every age group is equally represented, and we know that isn't true but just for the purposes of argument, let's assume that there are 10 age groups up to age 70, and the first age group is the 0 to 14-year-olds, would that be roughly reasonable?
A. Again I would refer you to the UNSCEAR report. I don't carry those sort of figures around in my head I'm afraid.
Q. No, you don't need to. I'm just saying that we can get some idea -- I mean not as experts but just as ordinary people -- of the approximate population of 0 to 14-year-olds in a population of 3 million. I mean, for example --
A. If you look at the report, I think you'll find the accurate figures are there and that would be far better than me speculating.
Q. It wouldn't be a speculation because we need to show whether the ICRP risk model -- or this is sort of where I am going here --
A. I can't see why this is particularly relevant when we

are not talking about thyroid cancer in the appellants.
MR JUSTICE BLAKE: I can see you are laying foundations for a question but I think you might want to get on to the actual question and put the proposition you are doing because otherwise it is always a risk we are going to be distracted into an analysis of the Chernobyl children. I can see why it might have relevance to some of these questions but if you would like to get to the point.
DR BUSBY: My Lord, the point is -- I am not -- the problem is I have to rely upon the expertise of Professor Thomas, which is considerable -- it is her area of research --
MR JUSTICE BLAKE: But it's --
DR BUSBY: -- to tell us whether the ICRP risk model --
MR JUSTICE BLAKE: If you want to find out from -- if you want to put the question that you are leading up to, it's probably a good time to do so.
DR BUSBY: Does the ICRP risk model predict the enormous increase in childhood thyroid cancer that was found after the Chernobyl accident on the basis of the dose of 500 millisieverts --
A. No, because --
Q. No?
A. I'm sorry, you are using the wrong context for this. You can't base it on one single dose which is a mean

dose which only a certain number of people were exposed to. The risk model is much more complicated than that and I think you are better directing your questions to somebody who is a trained epidemiologist.
Q. I will do that.
A. My interest is in the molecular pathology of thyroid cancer and I'm not a trained epidemiologist.
Q. So --
A. I think the context of your question is wrong, I'm afraid.
Q. So I think what your answer, is yes, or you don't know?
A. I'm not answering the question because I don't think I'm equipped to answer that. Based on your question -- does 500 millisieverts predict the increase? -- I would have to know exactly how many children were exposed to 500 millisieverts to answer your question and I don't have that information I'm afraid.
Q. We can work that out, can't we?
A. No, we can't work that out. The dosimetry needs to be worked out. I'm sorry, all the information you need is in that UNSCEAR annex and you should be able to tell from that.
Q. I'm sorry, I'm just checking my phone is off in case it starts bleeping at me.
All right, I don't think I can go any further with

that line of argumentation. I just now want to go to Fukushima, where we have -- so my question here is: was there an increase in thyroid cancer after the Fukushima Daiichi accident.

A. No.

Q. There was not?

A. There was not. There was a screening programme put in place which detects thyroid cancers that occur in that population earlier.

Q. Right.

A. But that does not constitute an increase due to the radiation.

Q. No. Well, can we now go to SB6/75. Do you have it?

A. Yes.

Q. Do you agree that this paper by Tsuda and co-workers found a significant increase in thyroid cancer as a result of ultrasound examination of a population of 380,000 people aged 0 to 18 in the Fukushima Daiichi constituency or whatever?

A. Whether it is an increase, you need to have a control population to determine whether what you are seeing is a screening effect, therefore it would have been there anyway, you just didn't know it was there, or whether it's a genuine increase. If you compare this with other papers that have been written looking at control

populations at Iamori and three other prefectures using exactly the same technology, the frequency is exactly the same. And in fact this paper caused an awful lot of controversy because it's so poorly written and I think my Lord in the bundles there are several angry papers saying how bad this paper actually is.

MR JUSTICE BLAKE: Well, I just want to get a gist of the answer. So you don't agree with the proposition --

A. I don't agree -- they chose -- they have detected more thyroid cancers. Whether that is an increase is a different matter.

MR JUSTICE BLAKE: You make a distinction between the detection of more thyroid cancers --

A. And a genuine increase.

MR JUSTICE BLAKE: -- and an increase in the rate of detection?

A. Absolutely.

MR JUSTICE BLAKE: I'll just get that down first, if I may.

(Pause)

DR BUSBY: So --

MR JUSTICE BLAKE: Hang on just a second.

DR BUSBY: All right.

MR JUSTICE BLAKE: That's your first part --

A. That's a very important distinction, my Lord.

MR JUSTICE BLAKE: I've got that down. Thank you very much.

The second is you say this paper has been subject to some criticisms as to methodology.

A. Huge criticism.

MR JUSTICE BLAKE: Right.

A. By people who are far better qualified to look at the methodology in this paper than I am.

MR JUSTICE BLAKE: You think we have the benefits of those papers somewhere?

A. You have. I certainly made sure they were in your bundle, my Lord.

MR JUSTICE BLAKE: Okay. One second.

The third part was you say that you would need, in order to answer the question that Dr Busby has posed to you, i.e. whether it's an increase as opposed to a detection of greater numbers --

A. Exactly.

MR JUSTICE BLAKE: -- you also have to look at other material --

A. You would have to compare it with a control population. We do not routinely use this sort of sensitive ultrasound to screen populations of this age. So you have to have some form of control to compare this with to know whether it is a genuine increase --

MR JUSTICE BLAKE: Yes.

A. -- or whether it's actually due to the method you are

using to detect.

MR JUSTICE BLAKE: The question I am now going to ask is whether to your knowledge that exercise has been conducted.

A. Yes.

MR JUSTICE BLAKE: It has been?

A. It has. Not on the same size population, and in fact the Japanese were advised because they took expert advice before they set up these surveys, to do a control population of a similar size. But as I'm sure you can imagine it's an extremely expensive and time-consuming thing to be doing and you worry more people by screening a population. So on balance they decided they would conduct a smaller study in prefectures that were not affected because obviously there is a difference as well with the number of thyroid abnormalities you find in different populations. So they chose other prefectures that were not exposed.

MR JUSTICE BLAKE: So they studied other prefectures on a smaller scale, then they have the control at, what, screening at the same age?

A. Screening at the same age and exactly the same technology, which is important because I'm sure you're aware ultrasound varies.

MR JUSTICE BLAKE: Well, yes. I could be.

A. Your medical colleague I'm sure will be aware.
MR JUSTICE BLAKE: So that's the point.
A. Mm.
MR JUSTICE BLAKE: Right. Okay. Thank you.
DR BUSBY: So let's just get this absolutely straight. Professor Tsuda here, who wrote this paper into a very estimable journal that was a journal of the -- I read it here for you. It's the International Society for Environmental Epidemiology.
A. Yes.
DR BUSBY: Which is a well respected organisation that was founded --
A. I think it has less respect after publishing this from an awful lot of very good epidemiologists, I'm afraid.
Q. It would therefore have been through quite stringent peer review?
A. Peer review is a mixed bag. Sometimes the peer review is good, sometimes the peer review is not so well conducted. So I wouldn't necessarily say that peer review per se guarantees good papers.
Q. But this Tribunal, the level of proof in this Tribunal is much less stringent so could I ask you if you would consider that there might possibly be an increase, a significant increase in thyroid cancer after an exposure from Fukushima?

A. No, the doses were 100 fold lower -- yes, 100 fold lower. They were 4.2 millisieverts was the average thyroid dose in children from that area. 360,000 children were exposed to varying doses --
MR JUSTICE BLAKE: Keep it slow. I know you are very enthusiastic to inform us but absorbing the information, let alone writing it down, is quite a challenging task.
A. Sorry. The dose was much, much lower than from Chernobyl, so instead of 500 millisieverts from the evacuated population mean dose, it was 4.2 millisieverts mean dose. So the exposure was lower, the dose was lower, therefore the effect would be predicted to be lower than was seen at Chernobyl.
It was a much smaller population, 360,000 children, of the age that we know is more susceptible to iodine --
MR JUSTICE BLAKE: In Japan or in Chernobyl?
A. 360,000 children in the Fukushima prefecture and in fact very small -- the Fukushima prefecture is huge, so it's a very small part of the prefecture that is affected by this, whereas for a comparison in the areas around Chernobyl, 10 million children were exposed to varying doses but the average in the most contaminated area was 500 millisieverts.
MR JUSTICE BLAKE: Thank you.
A. So --

MR JUSTICE BLAKE: Yes?
A. -- if you just simply do the maths and you use the frequency that we would expect from the data we have from Chernobyl, you would see less than one cancer if the dose had been the same as at Chernobyl, and because the dose is so much lower you are just not going to see any thyroid cancers. So the thyroid cancer incidence rate will not be raised statistically significantly in such a way that we could see it.
MR JUSTICE BLAKE: Yes.
DR BUSBY: Well, just parenthetically here, you just mentioned to the Tribunal, and correct me if I'm wrong, that 10 million children in Chernobyl were exposed to --
A. In the areas that were bordering Chernobyl, so that includes northern Ukraine, southern Belarus and in particular the Bryansk area of Russia as it now is
Q. We just agreed that the whole population of Belarus is 3 million.
A. I'm not talking about Belarus. I said northern Ukraine --
MR JUSTICE BLAKE: Other countries outside Belarus were affected by Chernobyl?
A. Yes, it wasn't just Belarus.
DR BUSBY: Do you know what the population of the Ukraine is?

A. Huge, but in that area it was only a certain part of the area of Ukraine that was -- again, if you look in UNSCEAR you will find all of these details.
DR BUSBY: I think we need to go to these details now.
MR JUSTICE BLAKE: Right.
DR BUSBY: Because if the population of the whole of the Ukraine is 8 million and the population of the whole of Belarus is 3 million, that means we have, if I've done my sums right, 11 million people adults in --
MR JUSTICE BLAKE: I think you had better look at the UNSCEAR documentation.
A. My Lord, not everywhere in Belarus was exposed. Teppus was not exposed, which is the Northern Oblast, and it's only the Northern Oblasts of Ukraine, and there were about five or six of them, that were actually exposed to the iodine. Because it has such a short half life, it does not go very far.
MR JUSTICE BLAKE: I think at the moment there's simply a debate about how large a population is affected.
DR BUSBY: I think that is rather the point, my Lord.
MR JUSTICE BLAKE: I have that bit, but the point is we are not going to be making good use of the time by having an exchange as to how many people live in different parts. So if you have the hard data, let's go to it and then the witness can comment upon it, but rather than

debating between the two of you how many people live in the northern part of Ukraine, Russia, et cetera, et cetera, et cetera, either if you have the goods let's go there, and if not we'd better move on.
DR BUSBY: My Lord, the witness is giving evidence about the increase in thyroid cancer in Fukushima. She is depending upon an argument relating to the population exposed after Chernobyl. She has told us that there are 10 million children exposed after Chernobyl. This is frankly absurd --
MR JUSTICE BLAKE: Dr Busby, are you going to go to the documentation about these matters or not?
DR BUSBY: I'll leave it at that, my Lord. I think we've made the point here.
MR JUSTICE BLAKE: I'm not sure you have made any point, but if you want to, please do. So put your questions.
DR BUSBY: Yes. Do you agree that the population of children exposed to radio-iodine following the Chernobyl accident cannot possibly be anywhere near the 10 million that you have just told us?
A. No, I absolutely do not and I think you should read that document. I'm sorry, that is common knowledge.
MR JUSTICE BLAKE: I think we have that point. Thank you, that will do.
DR BUSBY: Now we go back to Tsuda. So the increase in --

according to Professor Tsuda -- was 50 fold. He said so in the abstract. Do you agree with that?
A. No, he says it in the abstract. I don't agree with his finding.
Q. That is what was found -- all I am saying is that was found in the survey. So --
A. That was his conclusion from analysing the data which is actually public data. He's not a member of the people who are doing the Fukushima health management survey and I suspect this data was taken off the Fukushima Medical University website where they make all of their data available.
Q. Thank you. So your position then, just to summarise, is that neither the increase -- that the increase in Fukushima from thyroid cancer could not have been caused by the exposure because the dose was too low?
A. Yes, and it's solely due to screening.
MR JUSTICE BLAKE: She is disagreeing with the proposition that there is an increase.
A. Absolutely. There is no increase.
MR JUSTICE BLAKE: She says it is earlier detection. Come on, we've had that answer, so you can't slip under the cover there, I'm afraid.
A. I think you'll find there are several other people who agree with that stance, published in The Lancet very

recently.
DR BUSBY: I'm sure there are.
Also you said you had no possible doubt about the proposition that those thyroid cancers -- or not thyroid cancers but that there is a possibility of an increase in thyroid cancer following Fukushima because you say the dose is too low?
A. Yes, and actually the second results of the survey are now out and they show a decrease, which is entirely what we would expect because this was a screening artefact. We do screen for mammary cancer to make sure we pick up tumours earlier so this screening effect is not unknown for other tumour types for other reasons.
Q. Was there not a screening -- Professor Tsuda here says they screened for thyroid cancer shortly after the accident, two years after the accident?
A. They staged the screening, because it's a large amount of work to do this and you have to be especially trained to use the equipment and to interpret things, so they staged the screening, they started two years afterwards and it took about two years to screen those who were willing to come forward for screening. Many people have moved away from the area and actually don't want to come forward for screening.
Q. They found nothing?

A. I didn't say they found nothing. They found an incidence of thyroid cancer which is exactly where we would estimate it would be from other control studies.
Q. I don't think I can take this one any further. Thank you very much for that. We'll move on and we'll move now back to the uranium paper which I showed you. That's SB7/101. The uranium paper written by Alexander Miller.
MR JUSTICE BLAKE: Can we put SB6 away or do you want to come back to it?
DR BUSBY: Yes, we have finished with thyroid cancer, my Lord.
MR JUSTICE BLAKE: Thank you.
DR BUSBY: This a paper called "Depleted uranium catalyzed oxidative DNA damage: absence of significant alpha particle decay".
MR JUSTICE BLAKE: Just remind me of the tab.
DR BUSBY: It was SB7/101.
MR JUSTICE BLAKE: 101, thank you.
DR BUSBY: Previously it was just an abstract.
MR JUSTICE BLAKE: Yes, right, so we can slip this in there.
DR BUSBY: So I think it might be easier, Professor Thomas, if we just looked at the abstract.
A. I want to make some comments about the methodology as well.

Q. Of course, of course.
MR JUSTICE BLAKE: We have the abstract at the head of the paper. If we turn to the actual thing you put in last night, Dr Busby, the abstract at the head of the paper is the same as the document that was formerly in the bundle?
DR BUSBY: It's the document that was presented last night and has now been printed and put in with the abstract.
MR JUSTICE BLAKE: Right. If you want to draw the attention of this witness to a statement in the abstract, now that she's seen the paper she can give you an answer.
DR BUSBY: It's a very simple question. Do you agree that this paper shows that uranium seems to have an anomalously high genotoxicity in this study?
A. I don't think it's anomalously high. I think it's more or less what we would have expected from a high -- a heavy metal like this. It's interesting they used depleted uranium. I would have liked to see a control where they used stable uranium and then you could have a handle on whether it was related to the radiation or whether it was related to --
MR JUSTICE BLAKE: Slow down.
A. Sorry. This, to me, is straight metal ion toxicity, which you would predict, which we know heavy metals are genotoxic. It has a relationship with dose, which we

would also predict. I think if I was looking for an effect that separated alpha from the effects of the general genotoxicity of uranium I would have liked to see a controlled platform that used stable uranium in the same doses. Then you could say whether depleted uranium, which is the subject of this, has a different toxicity from that you observe from stable uranium.
MR JUSTICE BLAKE: Right. Just for my benefit, at least, I am getting the following summary answers; tell me if this is an over-crude simplification.
(1) the results recorded in this article you do not consider to be anomalously high?
A. No.
MR JUSTICE BLAKE: (2) you consider it to be a study of metallurgy?
A. Yes.
MR JUSTICE BLAKE: And (3) you would have preferred to have seen a comparison between depleted and stable uranium?
A. Yes, because that would given you the answer as to whether the depleted uranium was worse than normal uranium.
MR JUSTICE BLAKE: Is there any other part of your answer that I missed out?
A. No, that's absolutely fine, my Lord.
DR BUSBY: We'll stay with this now but I want to take you

to -- because I'm a bit confused about this concept of stable uranium, Professor Thomas, so could we see SB -- let's see, what is it? -- SB6/73.
A. Could you tell me the ...?
Q. SB6/73.
A. So not one of the new papers last night.
MR JUSTICE BLAKE: No, we are going back --
A. SB6/73.
DR BUSBY: We need to look at that as well whilst we have this one open as well.
A. This is just a list of decay tables; correct?
Q. Correct. Correct.
Now, I thought it might be useful for the Tribunal to have a list of the uranium isotopes that exist in nature, natural uranium isotopes. I wondered if you would tell us which of these isotopes you consider to be stable uranium?
A. You don't have a decay table where there is a stable isotope because it does not decay.
Q. I see. But actually may I put it to you that there is no such thing as stable uranium?
A. I think you probably need to check that because I think that is untrue.
Q. Right.
A. So every single chemical element has a stable isotope.

Q. All uranium is radioactive, Professor --
MR JUSTICE BLAKE: You can't give evidence.
A. It doesn't state that in any of the papers I read.
MR JUSTICE BLAKE: Put a question and we'll get an answer. I think we have a disagreement with the proposition that there is no such thing as stable uranium.
DR BUSBY: That's as far as I need to go; there's no such thing as stable uranium.
So you are saying that this table from the federal agency is actually -- it omits stable uranium because it's not radioactive?
A. I would probably need to check that. If you are adamant I can quite happily check that but I don't have the information here.
Q. It might be wise.
A. In any case it has an extremely long half life.
Q. Well, that's a different point.
MR JUSTICE BLAKE: Please can we have questions rather than two speeches.
DR BUSBY: Yes, my Lord.
So may we go back to the depleted uranium catalysed oxidated paper we were just looking at?
A. Just a second. I am going to have to get that back out again.
Q. Sorry.

MR JUSTICE BLAKE: I know we may have to jump around, but --
DR BUSBY: I thought --
A. Which bundle was that?
MR JUSTICE BLAKE: We are back to 7, I think, tab 101. I think our visit to 6 was simply to examine whether you are right when you say that there is such a thing as stable uranium.
DR BUSBY: We can put that to another expert.
MR JUSTICE BLAKE: I happen to have read part of this paper this morning, although I don't pretend to understand it, but the phrase used here is "natural uranium". Is that different from stable uranium?
A. That's what I understood to be stable uranium, but, my Lord, I will happily check and if I am wrong I will admit it.
MR JUSTICE BLAKE: For the purposes of myself following the answers -- I know others will be much better informed -- would you agree that what you refer to as "stable uranium" might be referred to as "natural uranium"?
A. Yes.
MR JUSTICE BLAKE: So at least we have that is the issue.
A. The natural uranium will be a different isotope, that is for sure. I would need to check whether it would be stable in terms of it does not admit irradiation of any type over any half life.

DR BUSBY: Right, good.
Well, all I want you to go to here is that you have said that you believe that what Professor Miller has found here is a heavy metal effect?
A. Yes.
Q. Right. So if people were exposed to uranium at Christmas Island you think that it's possible that they might have received the same sort of genetic damage as Professor Miller is finding here, but from a heavy metal effect?
A. No, because it depends on the concentration again. You keep forgetting that there are differences in concentration and different concentrations, i.e. doses in this case, have different effects. I can quote you the actual human daily intake of uranium in the United States. It's 1.5 micrograms per day. So everybody is exposed to uranium and you cannot avoid that. There's some areas of the world will have slightly higher depending on their geology.
Q. Quite, but that wasn't my question. My question is: if they were exposed to stable uranium -- what you call stable uranium -- from the bomb that Professor Sawada was talking about, the particles that were coming down from the bomb, if all of that was so, and I agree maybe you may not think that's possible, but if it happened

would it be possible that this heavy metal effect that you're talking about that has been found by Professor Miller might have caused genetic damage to the veterans?
A. I would think it was vanishingly unlikely and I'll explain why. These are in vitro studies, where you have dissolved something in water and you have done the experiment in vitro. As we discussed at length yesterday, many forms of uranium are insoluble. If you take in a particular dose of uranium most of it is excreted, so the amount that gets to your cells in vivo as opposed to an in vitro assay is markedly different and if you don't take that into account then you don't understand the difference between in vitro and in vivo experiments, which is critical.
Q. Of course, but I think we agreed or you agreed that it was possible that some uranium could get to the DNA --
A. In very small quantities.
Q. In very small quantities, yes. Let's say that that uranium, the very small quantity as you put it that gets to the DNA might have -- if it were stable uranium as you say she is using here IT might have a genetic effect that is mediated through chemical genotoxicity?
A. I would think at the doses that it is likely to reach the cells it would be vanishingly small.

Q. But finite?
A. I don't know what you mean by "finite".
Q. Well, it would be more than zero?
MR JUSTICE BLAKE: Measurable?
A. Well, in that case we're all suffering from that because we all intake uranium, so we must have mechanisms that surely protect our bodies from things like that, otherwise we'd all be suffering the consequences.
Q. Well, we all die, don't we, Professor?
A. Sadly.
Q. Yes.
A. But that doesn't mean it was due to uranium.
Q. I think that's as far as -- well, actually no, it's not as far as I can take it. I need to go forward with this one now. Let me see. Yes, we are going to put Professor Miller away now and we are going to go to SB6/87.
A. A paper by Craft, yes?
Q. This is a review article on the effects of uranium. We are going to go to the section on --
A. I have not read this paper so forgive me if I have to stop and read some of it.
Q. Well, in that case it's probably a bit unfair to ask you questions about it and I'm aware of the time constraints and I have a lot of other things to ask about. But

effectively this paper -- if I could summarise it -- you may want to have a look at it. If you want 10 minutes to read it --

MR JUSTICE BLAKE: Are you in the same position? (Pause) One of us has the paper; two of us have the abstract. We'll try and catch up on that.

DR BUSBY: Right, well, in that case since there is rather a lot of it, would you accept the proposition -- this a question -- would you accept the proposition that this paper reviews a lot of evidence that depleted and natural uranium have significant health effects?

A. Actually, no, I disagree with that because on several of the paragraphs I've just quickly looked at now:

"Animal studies also indicated no adverse cardiovascular effects following oral inhalation exposure to uranium."

I'd have to read this --

Q. It's unfair to spring it on you and --

A. Also I note that it's mainly animal and as I've said before, using animal studies to predict human toxicology is fraught with difficulties.

Q. So can we now go, therefore -- we'll put that to one side and we'll go to the paper by Irena Guseva Canu and I think a lot of other workers from the French nuclear industry.

A. Yes, I know --

Q. SB6/84.

MR JUSTICE BLAKE: So the same bundle back to 84, is it?

A. No, it's one of the papers which came in overnight, my Lord.

MR JUSTICE BLAKE: Oh right.

DR BUSBY: I think this is ... no, that's not the right one.

MR JUSTICE BLAKE: Where do we put this? Which tab?

MS BUSBY: It's a new paper, my Lord.

MR JUSTICE BLAKE: I have the paper. Which tab?

MS BUSBY: It doesn't have a tab.

MR JUSTICE BLAKE: I thought this was an expansion of the abstract.

MS BUSBY: No, it was given to the -- last night.

MR JUSTICE BLAKE: Yes. So this might be a candidate for 22. (Pause)

DR BUSBY: Do you have a copy of this, my Lord?

MR JUSTICE BLAKE: "Cancer risk in nuclear workers." Yes, thank you.

DR BUSBY: Okay, thank you.

MR JUSTICE BLAKE: Could we put this behind tab 6? Because that tab 6 is papers that Dr Busby is handing up.

MR HEPPINSTALL: Yes, or I think maybe a new tab I would recommend in SB22.

DR BUSBY: So everyone has a copy in their hand.

MR HEPPINSTALL: I can't reach mine but whatever the next tab number is in 22.

DR BUSBY: Well, I won't go to more than just the abstract here. This was a study that was done of a lot of French nuclear workers who worked only on uranium so the exposure -- a lot of the evidence in this case is about external radiation. Would you agree?

A. External and internal. I think if you read the rest of the paper she does actually state there is quite a considerable internal radiation as well because she talks about cardiovascular effects, lung effects, bone effects. Yes, it's not just external, I think you'll find.

Q. This is primarily a study of people whose exposure was to uranium. Do you agree?

A. Yes, but that doesn't necessarily mean it's external because uranium millers will actually take in uranium dust as well.

Q. I think that's the point, Professor Thomas. We're talking about internal, they're taking in uranium --

A. Sorry, I thought you said external. I apologise.

Q. All we need to note from this, if I can read it to you, it says:

"Workers occupationally exposed to uranium [this is from the abstract about halfway down] appear to be at

increased risk of mortality ...(Reading to the words)... and inaccurate assessment of internal exposure."

Would you agree with that?

A. No, I don't because if you read the rest of the paper she says in the conclusions the exact opposite.

MR JUSTICE BLAKE: Where does she say it the exact opposite?

A. If you look at "In conclusion", the first paragraph at the bottom of page 13.

MR JUSTICE BLAKE: Right. Let's just move on to there. Yes.

A. There's an interesting use of English here.

MR JUSTICE BLAKE: Right. So you point to the passage "conclusion", page 13?

A. Yes:

"Our review shows that in several cohorts of workers with potential occupational exposure to uranium cancer mortality risk was increased non-significantly."

Now, I do not like people who put things in that term. In science you do studies that show either a significant increase or they do not show a significant increase.

MR JUSTICE BLAKE: So --

A. It's not a significant increase, so therefore there is no effect. If you go through --

MR JUSTICE BLAKE: Well, what does the next sentence mean?

A. "Among 18 cohorts, a few studies presented a significant excess of a priori suspected sites."

If you read the paper further, it also tells you that these workers were exposed to things like silica and vanadium. In the early years of the industry the health -- people didn't really take that much notice of compliance with health regulations and so a lot of dust was -- these workers were exposed to a lot of dust and she points out under the respiratory system on page 4 in the middle of that paragraph:

"The increase was significant among men ..."

MR JUSTICE BLAKE: Sorry I am plodding my way through rather later, I am sorry. Yes, I'm now there.

A. "The increase was significant among men who began work before 1955 when exposures to uranium, silica and vanadium were presumed to be high. The role of other chemical exposures and of tobacco was not assessed as data were lacking."

That's really important you assess that when you are looking at respiratory effects.

MR JUSTICE BLAKE: "Hence this study is rather inconclusive with respect to the association between lung cancer mortality and internal exposure to uranium during milling."

A. Yes.

MR JUSTICE BLAKE: All right.

A. Again, if you look further there are other evidences of that. Just to take you to the last paragraph of the paper, "Future directions" on page 14.

MR JUSTICE BLAKE: "Future directions", yes.

A. It says:

"Although a substantial body of epidemiologic ...(Reading to the words)... alpha particles from uranium was very limited."

So I think the conclusions from this paper are very different from that stated in the abstract and that was my point yesterday when I refused to review a paper solely on the abstract. The abstract is what gets your paper published and if you present something that looks positive it's much more likely to get published. That's why abstracts should never be taken out of context.

MR JUSTICE BLAKE: Well, you got an answer.

DR BUSBY: Yes. I have a question, can I read to you from the -- whilst we are dissecting this paper, I think the point of this paper here is in the conclusion.

A. Yes.

Q. At the bottom of the left-hand column of page 13 --

MR JUSTICE BLAKE: Yes.

DR BUSBY: -- you can see it says, and I'll read it:

"Statistically significant dose response

relationships with internal radiation dose ..."

A. Sorry, I can't see where you are. Okay, I've got it.

Q. The last line but one starts:

"Statistically significant dose response relationships with internal ...(Reading to the words)... and upper area digestive tract."

A. But I think from her conclusions you can see she is not looking at just two studies, she is looking at the body of data and when you are looking for a small effect by pure chance you will find it in some studies and not in others. So you don't know whether that is genuine and that's a big problem with these studies.

MR JUSTICE BLAKE: As I read that sentence, forgive me if I've misunderstood, it wasn't referring to two studies but reports on two sites.

A. And she cites one paper, which is one study.

MR JUSTICE BLAKE: Right, so it's one study on two sites. Do you know that paper --

A. I don't I'm afraid, my Lord, and I didn't have time to look at the references.

MR JUSTICE BLAKE: I am not suggesting you should have done, I am just asking the question.

A. But the general consensus is that there is no, what we would regard in science as scientific evidence of an effect of uranium and that's a general consensus from

many different sources.

MR JUSTICE BLAKE: Even in lymphatic and haemaopoietic sites?

A. Yes. The other thing you need to be aware of when you're looking at this sort of information, my Lord, is many of these studies have workers that were exposed to much higher levels than we would find now, so you have a cohort exposed to higher levels but in the generality most of the workers were exposed to much lower doses because of changes in health and safety. That doesn't just go for uranium, it goes for all the other particulates that they are exposed to.

MR JUSTICE BLAKE: Pause there. Dr Busby will ask any further questions on this paper that he thinks are appropriate.

DR BUSBY: Only one question, my Lord. The question is: do you think that the evidence reviewed in this paper persuades you that there may be an excess risk from exposure to internal uranium at low doses?

A. I think it is impossible to say there is no risk. As I said earlier yesterday in response to Mr ter Haar it is extremely difficult to say nothing has no risk, it's just a question of how small that risk is, and when you compare that risk with other risk factors that produce that same disease is it a risk that you should taking

into account? Or is it an irrelevance so that you forget the other risks that create that disease?

Q. Thank you.

MR JUSTICE BLAKE: Is irrelevance a scientific measured --

A. No, I think, my Lord, what you would say if the risk is infinitesimally small you focus on protecting the workforce from that single risk, you have to make sure that in doing that you do not produce more risks because you are so focused on that one risk. I can give you a very good example of that in Fukushima. They are so focused on protecting the workers from the radiation risk they make them wear full body suits in 40 degrees of heat and several Japanese workers there have died of a heart attack and heat stroke because they were so focused on that single risk.

MR JUSTICE BLAKE: Fortunately our task is not going to be to devise a health and safety regime to eliminate the risks from uranium. We have to focus our minds upon a causation issue. I was just wondering whether you were going to be lured into "infinitesimally small" as having a statistical meaning.

A. Well, if you can't see it statistically then it is so small that it becomes an irrelevant risk. That is our general scientific understanding of something that is not significant, it is infinitesimally small -- so small

that we can't detect it.

MR JUSTICE BLAKE: If you can detect it?

A. If you can reliably detect it -- and I'm afraid when you do human studies you can be misled.

MR JUSTICE BLAKE: If you can reliably detect it?

A. If you can reliably detect it, you need to take it into account and then you can decide whether it is a risk that in the general pool of risks that affect your health it is something that needs to be taken account of.

MR JUSTICE BLAKE: Right.

DR BUSBY: Whilst you were talking about that paper, Professor Thomas, you mentioned that non-significant increase, and you talked about the idea of a significant increase and a non-significant increase. Could you distinguish between an increase which is not statistically significant and a non-significant increase?

A. It depends on the P value as to whether something is statistically increased or not, which I'm sure you're aware of. And it will depend on the study design, the numbers, and I'm not a statistician but you will be talking to a statistician later and I'm sure he can give you a much more concise definition.

Q. I will, thank you.

A. I'm afraid all of our science is based on something that is significant. If it is not significant it's not something we will go back --

Q. You mean it's not statistically significant?

A. Yes. Well, I don't know there's any other form of significant that we would accept in science I'm afraid.

Q. Of course. But this Tribunal may not understand that there is a difference, that you could have an increase which is in fact representative of something real, but it might not be statistically significant --

A. But it isn't real in the general population.

Q. -- because the numbers are too small.

A. That means your study needs to be done again. That means you can't define the risk because your study may be very misleading and I hate to say an awful lot of the studies in this area are too small to have statistical significance.

Q. Let's look at one that does. SB7/124. This is another one of the abstracts -- so we have the abstract at SB7/124. We don't seem to have the paper that we sent in last night.

A. I have it in my bundle.

Q. You have it, yes.

A. This is a paper by Zaire, is that right?

Q. This is the paper about chromosome aberrations in uranium miners.

A. Yes.

Q. Well, I don't have the paper in front of me. But going from the -- has everybody got it?

DR RAYNER: No, we just have the abstract. I think it's coming. (Handed)

MR JUSTICE BLAKE: Right. Which tab?

DR BUSBY: This was a study of uranium miners in which the uranium was measured in uranium excretion in the urine. So they knew how much uranium was in these people --

A. It was a cohort of 14 miners and 6 controls. Only 14 miners had the uranium concentration in the urine examined. So again a small sample size.

Q. Well, yes, a small sample size but if we go halfway down the abstract, and I'm sure we can find this in the paper as well because they can't make it up, they say:

"A sixfold increase in uranium excretion was recorded."

And if we go a bit further, then various other things were found too -- testosterone levels, neutrophil count, and so forth. You see all of those things say "P value of ..." -- if we say a sixfold increase in uranium excretion the P value is 0.001.

Then the reduction in testosterone was 0.008,

neutrophil count 0.004. But the thing I really want to draw attention is to a threefold increase in chromosome aberrations in the miners compared to non-exposed controls?

A. I'm sorry, with numbers this small this would need to be validated in a separate cohort. This is not good science.

Q. Why?

A. Because the numbers of people you've looked at is so small. You have a huge sampling problem there. You could have literally by accident sampled a particularly high population. This is not acceptable as good science.

Q. What does it mean, a P value of 0.0001?

A. P values, unless you know the sample size you are dealing with can be very misleading, and I'm afraid most people do not look at the statistics properly and there is little statistical advice in peer review. Some journals are now insisting on it because they're aware of things like this, where it looks good on the table, and that's what most people will read, but when you look at the number of people you studied you realise it's such a small population that it is highly suspect as a genuine P value that represents the population. I'm sure you can take that further with Dr Haylock.

MR JUSTICE BLAKE: Can I just check that I have your answer to the question. I think you are being asked to comment on upon the conclusion in the abstract of a threefold increase in chromosome aberrations and your answer is the sampling process was too small --

A. Yes.

MR JUSTICE BLAKE: -- for reliable conclusions of that sort to --

A. If we relied on information like this to make medical decisions we'd be shot and rightly end up in court.

MR JUSTICE BLAKE: So it's too small.

A. Yes, it's too small to be able to draw secure conclusions about the population from which it is derived.

MR JUSTICE BLAKE: So if you are presented with information of such a medical finding and you were curious to know more as to whether the proposition was correct, what would you need to do?

A. You'd fund a bigger study. You would need to find -- you could do it two ways. You can choose a bigger study with the same cohort, or even better, which is what we insist on when we do medical research into drugs is you choose another cohort and repeat the study then look for the biomarker in question.

DR BUSBY: Professor Thomas, a P value of 0.0001 is given in order to discount the possibility that this occurred by chance. Is that right?

A. That's what people generally think it is but actually that's when people don't understand statistics, because the population size from which that P value is drawn to know whether that might be representative of a larger population is extremely important. And again I'm afraid it shows that you should not just read abstracts. You must read the rest of the paper to look at sample sizes and things like that.

Q. It does say that in the actual paper though?

A. It does say what?

Q. It says that the P value is 0.0001.

A. I don't care what it says about the P value. I'm telling you the study is badly designed, and I' m sorry, you shouldn't be drawing conclusions from badly designed studies.

Q. Is it true to say that a P value of 0.0001 means it couldn't have occurred by chance except 1 in 10,000 times? Is that what a P value means?

A. It says it couldn't have occurred by chance with the design that you have used but if that design is not suitable to test your hypothesis then it doesn't tell you anything.

Q. But these people took uranium miners and studied --

A. They studied 75 miners. That is not statistically useful. I'm sorry. In medicine -- the human body is infinitely variable. You can't just select 75 and assume that's representative of a much larger number. It's wrong.

Q. I'll have to leave that one. I can't go any further with it.

A. Talk to Dr Haylock. I am sure he is going to be better qualified to give you chapter and verse than I am on that.

Q. Dr Haylock will do that.

So far we've had several pieces of evidence that I suggested show that uranium has effects on chromosome damage and on cancer so we're now going to another.

A. In your opinion, not in mine.

Q. We're now going to see another one. It's at SB7/119.

A. You will remember, of course, Dr Busby that I was asked to look at the radiogenic nature of this, not the genotoxicity.

Q. We would argue it's the same, Professor Thomas, it's only you that says that it's chemical.

A. I'm sorry, the two things are slightly different. One is genotoxicity caused by a chemical issue and the other one is caused by radiation. My estimations were based on radiation dose. I was not given information about

the uranium that might or might not be found in these people.
Q. But you read our papers?
A. I read your papers but I didn't have any information to work on that gave me individual dose amounts for uranium in those people.
Q. No, we don't have those.
MR JUSTICE BLAKE: Please, we have to ask questions. 119?
DR BUSBY: Yes.
A. 119?
MR JUSTICE BLAKE: It's an abstract.
DR BUSBY: Well, we have provided the paper, my Lord.
A. I do have the paper here.
Q. "Chromosome aberration analysis in peripheral lymphocytes of Gulf War and Balkans War veterans".
A. I think we can go -- I don't think I need the question, Dr Busby. If you look at the abstract, 13 British Gulf War veterans, that was their sample size. That is not sufficient to draw viable statistical conclusions on.
Q. I haven't asked you a question yet, Professor Thomas.
MR JUSTICE BLAKE: All right. Ask the question, please.
DR BUSBY: The question is: this paper describes a study of chromosome aberrations in Gulf War veterans who were exposed to uranium and they measured the uranium in urine, and found a significant excess of chromosome

damage. Could you comment on it?
A. No, I can't because (a) I haven't read it and also as soon as I read the abstract it would be something that I would not regard as a useful paper to read that would give me scientific value.
Q. Right.
A. 13 is not a big enough number.
Q. Right. So do you dismiss the --
A. I dismiss irrelevant studies that are likely to be misleading of a whole population. I'm sorry, I'm a scientist and I'm trained to do that.
MR JUSTICE BLAKE: I think we have that point. Is there anything else in the paper itself rather than the abstract that you would like to put to Professor Thomas, Dr Busby?
The answer is it's too small to make reliable --
DR BUSBY: No, my Lord. I don't see any purpose in that. She obviously has made her position clear on this study and we can move on.
So we'll move on to SB7/98.
MR JUSTICE BLAKE: Yes.
DR BUSBY: Does everybody have that one?
MR JUSTICE BLAKE: I have the abstract, not the paper.
DR BUSBY: Ah right, okay. Well, the paper was submitted.
MR JUSTICE BLAKE: It didn't reach us last night. We

received three papers last night. Canu, Miller and "Mortality and Morbidity". Some of them we got twice.
DR BUSBY: Well, we can rectify that, my Lord.
MR JUSTICE BLAKE: Thank you.
DR BUSBY: Professor Thomas, we have looked at a few papers which show genetic effects in people exposed to uranium.
A. Mm-hm.
Q. And your position is that you discount those effects because you say, despite the fact that they are apparently statistically significant, the numbers involved were too small for you to say that they were worth --
A. Representative of the population.
Q. Yes. Well, here is a paper about genetic effects in Gulf War veterans and you can see the title says:
"A population-based survey of 30,000 veterans."
Would that be a large enough study to --
A. Yes, but there is a slight problem with this which was raised in respect of your paper with de Messieres. This is a survey, a questionnaire-based project, and again unless you validate the responses in the questionnaire it is very difficult to be sure that what you are looking at is genuine and you don't have a biosample.
MR JUSTICE BLAKE: Okay.
A. Again you haven't given me time to read this paper at

length.
MR JUSTICE BLAKE: Do you want to read it now or not?
A. No, I don't think it's worthwhile.
DR BUSBY: If you read down on the left-hand side the little bit of blurb at the bottom where it says --
A. I know it's come from a reputable journal. I can see that but it doesn't mean that's right --
DR BUSBY: I don't think we are talking about the journal here. I was going to the fact that this was from the Environmental Epidemiology Service of the Department of Veterans Affairs, Washington DC.
A. Yes, I'm not saying that it is irrelevant. What I am saying is there are basic problems with this design of study and I can't -- if I look through, if you can point me somewhere where they said they validated this.
MR JUSTICE BLAKE: Look, just pause there. Have you had a chance to read this or not?
A. No, I haven't.
MR JUSTICE BLAKE: Right. So this --
A. I haven't read every paper in the bundles, my Lord.
MR JUSTICE BLAKE: I imagine you were entitled to get some sleep last night.
MR HEPPINSTALL: My Lord, there are two sets of papers received by the Secretary of State. One was three papers we passed on to Professor Thomas.

MR JUSTICE BLAKE: Quite.
MR OSMAN: We then received a much larger number of papers --
MR JUSTICE BLAKE: Well, it's too little, too late, I'm sorry. You were directed to provide all the papers last week and we made it plain last night that if you were going to ask questions of a witness she needed a chance to read it. Now, it's really -- I mean this is not effective cross-examination if you are introducing a whole paper at this stage in the game. How many more of these do you have up your sleeve, Dr Busby?
DR BUSBY: Well, it's not up my sleeve, my Lord. We were asked to provide them last night and we provided them.
MR JUSTICE BLAKE: Well, you failed to do so, so that's a failure because the person who needs it -- I think one of my colleagues has it in her pile but we haven't, but that doesn't really matter. I'm not concerned about myself, I'm concerned about the witness and it was not provided in time for her to read. Of course there we are. But I think if you want to show us the methodology of this paper, let's have a look at that, shall we? This is at page 2 under the heading "Methods".
A. Yes.
MR JUSTICE BLAKE: Do you just want to read that section to yourself?

A. Yes, it's interesting that they have 15,000 Gulf veterans --
MR JUSTICE BLAKE: Just read it to yourself. If you want us to break for 20 minutes we can take a break now.
DR BUSBY: I wouldn't mind a break, my Lord.
A. That would be good, thank you.
MR JUSTICE BLAKE: What I am anxious, however, is I am not going to be able to take a break every half hour.
DR BUSBY: I was going to ask you if I could eat an apple.
MR JUSTICE BLAKE: We'll take a break, you can eat an apple, you can read a paper, then we'll continue. It probably would be helpful, although I am not putting you in any handcuffs, just to have a sense if you could communicate with your colleagues how long your examination is likely to continue for because I know other people might be here today.
DR BUSBY: Given we have a break now, and we come back say 11 o'clock would be fine by me, then another hour --
MR JUSTICE BLAKE: I will say 5 past 11. I am not asking you to do it now. Think about it, tell your colleagues and if you can tell me -- it's more just about managing today's events rather than anything else.
DR BUSBY: Thank you, my Lord.
MR JUSTICE BLAKE: If this is important material --
DR BUSBY: Might I just say --

MR JUSTICE BLAKE: Let's try to ensure that before you put any further papers which are not in the bundles as prepared to the witness that she has had notice of it. Yes? Otherwise we just don't --
DR BUSBY: Yes, thank you, my Lord. We did actually send these in at 7.30 last night. But it takes a while --
MR JUSTICE BLAKE: I am not going to debate that. I have e-mails which would demonstrate the contrary.
(10.52 am)
(A short break)
(11.05 am)
MR JUSTICE BLAKE: Right, have you had a chance to read two papers?
A. I have read as quickly as I can. I would have liked longer, but I have the general gist. I am happy to answer questions on it.
MR JUSTICE BLAKE: While you are here it would be helpful if you can help us.
A. I will let you know when I get to the limit of my knowledge.
MR JUSTICE BLAKE: You have had your apple, have you, Dr Busby?
DR BUSBY: Yes, my Lord.
MR JUSTICE BLAKE: Good. So where do we go now? 98 --
DR BUSBY: I seem to have just mislaid the Kang paper.

MR JUSTICE BLAKE: It should be at tab 98 of SB7, I believe.
DR BUSBY: Thank you.
Professor Thomas, here is another paper that suggests that there may be some problems with exposure to depleted uranium.
A. I don't agree with your conclusion on that.
Q. So this is not a paper that suggests --
A. No, actually it says quite categorically in the conclusions:
"A combination of genetic and environmental factors may contribute to 20 to 25 per cent of congenital abnormalities."
So you'd have to bear in mind that this is not about depleted uranium, it's about exposure to a variety of different agents that the Gulf War veterans might have been exposed to. So I don't think it supports an argument about depleted uranium because it doesn't mention what the exposure was.
Q. But the exposure included depleted uranium, you agree?
A. We assume so. We are not told that in the paper and we are not told the extent of that.
MR JUSTICE BLAKE: Can you just draw my attention, please, to the conclusion to which you have just referred?
A. Yes, page 509, my Lord.
MR JUSTICE BLAKE: 509, yes, thank you.

A. It's in the paragraph beginning "A third limitation of the study". They are very honest about the limitations.
MR JUSTICE BLAKE: The second column, yes.
A. Okay, and if you read a bit further down it states:
"A combination of genetic and environmental factors may contribute to 20 to 25 per cent of congenital abnormalities."
MR JUSTICE BLAKE: Right.
A. If you follow that paragraph to its end it ends:
"Certainly Gulf veterans were exposed to many chemical, biological and physical agents suspected of being reproductive toxins."
MR JUSTICE BLAKE: So (1) the conclusion is too ambiguous to be uranium-specific?
A. I think there is no proof in here it is uranium. There may well have been other exposures that have contributed to that and you'd have to dissect that.
MR JUSTICE BLAKE: You started before the break to say something about the sampling methods. Is that relevant to what you want to say or not?
A. No, I would say having reviewed the paper they have taken considerable pains to examine whether there might be a bias and how that might be addressed by this study, so they have taken that into account.
MR JUSTICE BLAKE: That is in the section "Methods"?

A. That's in the -- yes, and it goes into quite considerable detail about allowing for various biases further on in the paper, my Lord. I can't find it exactly --
MR JUSTICE BLAKE: But if you are sampling veterans, there is a method of counteracting bias, is there?
A. Yes, they've taken account of the biases that may occur because of the methodology.
MR JUSTICE BLAKE: That's not an observation you would want to make of this paper?
A. No.
MR JUSTICE BLAKE: Righty ho.
A. I would like to point out you may read the title and think it was 30,000 veterans who were exposed to these agents. Actually it's 15,000 veterans exposed and 15,000 not deployed. So in other words the sample size is actually half what the title may have suggested to you.
MR JUSTICE BLAKE: I rather picked that up from the first line of the abstract. I looked at that round the title --
A. 15,000 is a substantial sample size.
MR JUSTICE BLAKE: Yes, good.
DR BUSBY: Well, I don't think we have -- I have your answer on this. Can I ask you, do you think that this paper

suggests there may be an association between exposure to depleted uranium and the congenital malformations that they found? There may be?
A. It's possible but without controlling for the other things that we know do affect reproductive toxicity that we know other Gulf War veterans were exposed to you cannot say it was definitely due to depleted uranium. It was one of the factors that we know might be involved but you can't prove it from this paper because it doesn't have the evidence in here to prove it.
Q. Of course. Quite so.
I think I now want to go to another paper of similar ilk, which is SB7/93.
A. This is the one by Araneta.
Q. This is Areneta. I mean there are a fair number of these papers. I just chose two just to make the point. There are a lot of papers where we see these increases in risk in Gulf War veterans. This is another one.
Would you accept that this paper gives evidence for birth defect excess amongst the children born to Gulf War veterans in these states of the United States?
A. I wouldn't be that strong in my conclusion as the authors themselves actually state in the conclusion at the end, my Lord, on page 259.
MR JUSTICE BLAKE: Shall we just get there?

A. Just above the acknowledgements, my Lord.
MR JUSTICE BLAKE: Yes, "conclusion".
A. "We did not, however, have the ability to determine if the excess was caused by inherited, environmental or synergistic factors or was due to chance."
So the authors themselves actually state in their conclusions they do not feel that they can draw any conclusions about the causality of these effects being due to being in the Gulf War. That's not my conclusion, that's their conclusion.
MR JUSTICE BLAKE: Yes. So both these papers, as I understand it, are studies of US service personnel.
A. Yes.
MR JUSTICE BLAKE: Are they of the men or the women?
A. Some of them are both. Certainly the first paper looked at the women as well.
MR JUSTICE BLAKE: Because women's reproductive --
A. Yes.
MR JUSTICE BLAKE: -- DNA can be affected as much as the men.
A. Interestingly they didn't find the effects in the women. They found it in the men --
MR JUSTICE BLAKE: I thought the sperm -- I thought yesterday we were looking in particular at male contribution to reproduction as vulnerable.

A. Yes.
MR JUSTICE BLAKE: But anyway, and are they finding some anomalous --
A. They are finding some anomalies which they cannot -- they don't have the data to investigate further.
MR JUSTICE BLAKE: But at least it can be said there are anomalies in terms of birth defects.
A. Whether they are genuinely caused by exposure to depleted uranium or whatever the cause is it's not clear but there are slight changes. They're not big changes.
MR JUSTICE BLAKE: But in the larger paper, at least, there are anomalies which may be caused by a variety of exposures and even if it's exposures during military service, although relevant in some respects no doubt, if the issue we're looking at here is what is the particular contribution of uranium or depleted uranium they are unable to distinguish that particular factor as to other risk factors during that period of service?
A. Yes, or even actually general risk factors because we know genetics affects outcome.
MR JUSTICE BLAKE: I think I have that as well but I am just trying to absorb the information from the summaries. We are being told there were other factors in military service and other factors anyway in these informants' lives which might have affected the outcome?

MR JUSTICE BLAKE: Yes.
A. I am not saying they are wrong but they need to be interpreted correctly.
DR BUSBY: Professor Thomas, you agree with me that this study came from the Department of Defense, Center for Deployment Health Research Naval Health Research Center, San Diego?
A. Yes.
Q. This is an authoritative study, is it not?
A. Yes.
Q. It's just that you say that it might not -- that it wasn't depleted uranium, it was something else?
A. The authors don't give that information so you cannot draw that conclusion.
Q. Well, I don't -- I'm not --
A. They don't state it, I don't state it.
MR JUSTICE BLAKE: I think you have the answer. She's not criticising the study or the conclusion. She simply says the conclusion is so generally expressed as not to be depleted uranium-specific which I understood to be the answer to the question.
DR BUSBY: I understand, my Lord.
MR JUSTICE BLAKE: It may well be relevant whether they were claiming pensions for service in the Gulf which is fortunately not what we are going to be doing.

A. Yes. There's one other point of note as well. I haven't had time to read the paper exhaustively but some of the conclusions are drawn from much smaller sample sizes. In the 15,000, for example, they looked at defect severity status, okay, to see whether it was a much worse defect in those who were exposed to who were not. Then they looked at a much smaller subgroup of infants, 125, so I think the data has to be read very carefully to be absolutely certain whether the sample sizes in the subgroups that they've analysed does give you statistical viability for drawing the conclusions. That's positive and negative as well.
MR JUSTICE BLAKE: Yes.
A. So only two -- if you look at the figures there, it gives you only two of the 125 infants had a reported birth defect in the control population versus 9 per cent overall. They've only looked at 125, I presume only in the control population, or no, they were conceived prior to the father's deployment to the Gulf.
So again it's indicating there might have been something in their exposure in the Gulf but actually with low percentages like that to draw on a figure of 125 you don't have the same statistical security that you would have had if it was all 15,000. So just a note of caution on some of the conclusions drawn.

DR BUSBY: If I could just go to one point to just clear this up. You just told the Tribunal that the relative risks were very small.
A. I didn't talk about relative risks.
Q. Can we just go to the results where it says "results" in the abstract.
MR JUSTICE BLAKE: Shall we go to the results in the actual --
DR BUSBY: We can do that, but I hope that we can assume that the results in the abstract are not different from the results in the bulk of the paper.
MR JUSTICE BLAKE: Do you want to go --
A. I'm not disputing their results.
DR BUSBY: I thought you said they were rather small.
A. They said that themselves, not me. I'm not disputing their results. I'm just telling you it's not necessarily depleted uranium because you can't deduce that from this paper.
DR BUSBY: You agree the results were quite high?
A. I wouldn't call them quite high if you look at the confidence intervals of some of them, certainly span 1, and that would make me question whether it's statistically viable. If you sample the population again or chose a different population, would you get the same result?

Q. But we're not looking at the confidence intervals.
A. I'm sorry, you should be looking at the confidence intervals because that tells you an awful lot about the study.
Q. If we look at the confidence intervals it says:
"1.1 to 6.6. B equals 0.039."
A. It depends on which one you look at. There's a previous one there that says:
"Confidence interval 0.97 to 1.89."
Q. Well --
A. You've picked the highest one, Dr Busby. With respect, there are others there.
Q. I am looking at the one in the "results" section at the top, the "results" section in the abstract. The first one that they write about heart defects, aortic stenosis.
A. Where are you?
Q. In the abstract where it says "results".
MR JUSTICE BLAKE: Dr Busby is taking this point from the first page of the paper, the second bold type heading in the abstract "Results", "Infants conceived post-war ..."
Am I in the right territory?
MR HEPPINSTALL: The abstract was in a different format in the bundle.
A. Ah, okay.

MR JUSTICE BLAKE: If you go to the paper --
A. So this is still -- which paper is it now?
MR JUSTICE BLAKE: "Prevalence of birth defects."
A. Sorry, I was looking at the wrong paper in that case. That's why I couldn't find it.
DR BUSBY: Areneta.
MR HEPPINSTALL: I think, Professor, you need to turn to SB7/93 in the bundle.
A. Yes, okay, got it.
MR HEPPINSTALL: You don't appear to have this. (Indicated)
A. Yes, I do, it's behind.
MR JUSTICE BLAKE: Is that the first page of the actual --
A. The abstract should be identical.
MR HEPPINSTALL: That's the abstract.
MR JUSTICE BLAKE: I am not dealing with that abstract. I am dealing with the abstract in the article.
MR HEPPINSTALL: But Dr Busby is --
MR JUSTICE BLAKE: Well --
A. I think the wording is the same, my Lord.
MR JUSTICE BLAKE: Can we go back to the actual article because then we can stick --
A. I was looking at the wrong paper.
MR JUSTICE BLAKE: Fine. We've got the right paper?
A. Yes.
MR JUSTICE BLAKE: We have the "Prevalence of birth

defects", and we see on that first page what I believe is the same abstract. I haven't checked it so I can't be sure. We have background and results and I think so far I'm helping you to where Dr Busby is on that --
A. Yes, I've got it now.
MR JUSTICE BLAKE: Just look at those results there and Dr Busby will ask you a question. Just give her a chance to read that section.
A. Yes.
MR JUSTICE BLAKE: I think the question was really: do you say that those are small or do you have any comment about the statistical base on which --
A. No, I mean when you see confidence intervals that span 1 you do question whether it is a valid finding. Some of these do not span 1, so you would say that it may be a valid finding. There are huge confidence intervals on some of these as well which tell you it's an extremely variable result. So again there are certain things you look for in scientific papers that urge you to have caution interpreting it, whether is you can just spread it across the whole population, and the span of confidence intervals and the range of the confidence intervals tells you whether this is something that might be suspicious and might not be borne out if you did the study again. That's all I am saying.

DR BUSBY: But is it not true, Professor Thomas, that the reason for -- that the size of the confidence, the span of the confidence interval, is the actual size of the sample, so if there's a very rare congenital malformation then obviously the confidence intervals will be --
A. But if it's specific to the cause you are identifying you will expect those confidence intervals to be smaller, so if you have a variability like that it suggests there may be more than one thing that is leading to that result. And you have to take into account what the authors themselves say. They are aware that they have not controlled for inherited, environmental or synergistic factors. So this might be due to exposure to something in these veterans. It also might be likely to be due to other factors and in order to pin down which of the many factors that affect this phenotype, you would have to do more research and you'd have to control for those other factors. Then you could say with confidence what you would like to say, is that this is caused by depleted uranium.
Q. So it's your position that it may be some inherited congenital defect that is shared by the 30,000 or 15,000 Gulf War veterans. So it's not because of the fact that they were in the Gulf War but they accidentally or by

some unknown effect all shared some genetic defect which led to this --

A. I'm not alleging that all. Please don't put words in my mouth like that.

Q. Sorry, I thought that's what you said.

A. No, I'm not alleging that.

MR JUSTICE BLAKE: Ask the question.

A. There are many factors, one of which might be genetic factors, but I am not in any circumstances suggesting there might have been a genetic problem in certain Gulf veterans. I think that would be extremely wrong.

DR BUSBY: Thank you. All right, I'm going to try and pursue this genetic mutation argument back to Chernobyl.

So I want to look at SB6/89. Have we all got that?

First of all I should say that this paper has been -- is one that has my name on it, although it was essentially a paper by Professor Schmitz Feuerhake and I think you were here when she was talking about this.

A. I was here.

Q. Now what we have done, in case this not admissible my Lord --

MR JUSTICE BLAKE: No, no, you can ask questions about it.

DR BUSBY: Okay. So that saves us a lot of time because we printed it out.

MR JUSTICE BLAKE: Yes.

DR BUSBY: Have you seen this paper?

A. Yes, I have.

Q. It was put in. Okay.

A. No, I saw it before the trial.

Q. Now this paper refers to in table 1 -- if we can go to table 1. Got that?

A. Yes.

Q. It goes to a very large number of studies that show increases in congenital malformations after Chernobyl in various parts of Europe and Belarus and Ukraine, including some really quite closely studied and argued and measured relationships between radiation and this increase in congenital malformations.

So my question is: do you agree that all of this evidence that is referred to in this paper shows that there was an increase in congenital malformation in Europe in people who were exposed to radiation from the Chernobyl accident?

A. I have had the chance to read some of the papers cited here, because this is a review, it's not got any new data in it, so it's just a review of the studies.

Q. Correct.

A. So whether it proves its point depends on the data from which it's actually drawn. So I haven't read all of them because I didn't receive the paper in time to do

that. I have read some of them, and actually if you read a lot those papers -- I think we have them should we need them -- you'll find a lot of them say "We did not control for other factors such as folate", et cetera, which is known to affect particularly neural tube defects.

So I would be very concerned as a scientist in taking this paper as meaning anything more than a review and you need to go to the original references to look to see if there are other confounders in those studies. Virtually all of the ones that I have read, some of them actually state it themselves, but they do not control for the other things that we know affect congenital health.

Q. But some of them did?

A. The ones I read there was not a single one where they controlled for it and I'm sorry, they were also fairly small which again, all of my reservations about small studies come into play.

Q. So your answer to that is no?

A. My answer is these are not good papers. So the answer is no, they have not proven it to be statistically significant.

Q. But all of the papers show that it is statistically significant but you --

A. Actually most of them don't have any proper stats on them, to be honest.

Q. But you are saying you think the studies are too small, like you said before. That's right, is it?

A. I'm sorry. As a scientist that is my position.

Q. Of course. That's the answer.

MR JUSTICE BLAKE: I just want to understand your answer there. You are not taking issue with the paper, but you are saying the answer to the paper depends upon what is contained in the papers which have been reviewed?

A. Yes, the arguments set out in this paper depend on the validity of the studies that they are citing.

MR JUSTICE BLAKE: Are the studies those mentioned in table 1?

A. Yes, I believe they are. I think they are mentioned in the references as well.

MR JUSTICE BLAKE: Right. Now just using that table if we can -- does it go on to page -- yes, it does. Table 1 goes over two pages, does it? Two-and-a-half pages?

A. Yes, it does. It goes on to page 5 as well.

MR JUSTICE BLAKE: Which ones are you familiar with?

A. There was a whole bundle of papers that were handed out if I could have that back.

MR HEPPINSTALL: If you look at SB22, the new bundle, at tab 6 it has those papers from table 1 which Dr Busby

produced.
MR JUSTICE BLAKE: I think my tab is empty.
MR HEPPINSTALL: If you look at the index you can see it.
MR JUSTICE BLAKE: Yes, yes.
A. I would need to have the papers to be able to refer to them but unfortunately I haven't got a bundle SB22 here.
MR JUSTICE BLAKE: Can we provide a bundle for the witness?
MR HEPPINSTALL: I think your 6 would still be empty.
MR JUSTICE BLAKE: No, no, don't worry about me.
MR HEPPINSTALL: No, no, but I think the actual clip of --
MR JUSTICE BLAKE: Okay, all right.
MR HEPPINSTALL: I'll see if I can do that.
MR JUSTICE BLAKE: If this is important --
MR HEPPINSTALL: I can re-examine.
MR JUSTICE BLAKE: -- you can re-examine.
MR HEPPINSTALL: Yes, I can re-examine.
MR JUSTICE BLAKE: Well, I'm afraid I lost the answer. You are saying that the validity of the conclusion in the paper depends upon an analysis of the literature that is being reviewed?
A. Yes, because there's no new data in this paper.
MR JUSTICE BLAKE: No new data, and some of the papers you are familiar with, some you are not?
A. I've read very recently.
MR JUSTICE BLAKE: All right.

You weren't familiar with any of the papers until you were asked to read them?
A. I knew of them but I hadn't read them, you know, with fine --
MR JUSTICE BLAKE: With giving expert evidence in mind. Right.
How many papers are there in there?
DR BUSBY: There are about eight, my Lord.
MR JUSTICE BLAKE: Eight. Is there any point in finding out whether the witness has got any comments on any of those eight papers?
MR HEPPINSTALL: I can re-examine on that basis.
MR JUSTICE BLAKE: All right. I'll leave that to you.
DR BUSBY: This paper, Professor Thomas, I think you said that you read it before so you have read it -- it's not been sprung on you, I mean -- it also goes to -- it reviews other studies besides the Chernobyl studies that you say may not be valid, which also suggest that the risk from low doses of radiation are not properly estimated by the current radiation risk model?
A. No, I didn't say that at all.
Q. No, I'm sorry, I am asking you if you agree that this paper contains other evidence apart from the Chernobyl evidence?
A. It contains other evidence but I haven't read all of

those papers in detail to tell you whether I would agree with the evidence in those papers so I can't possibly comment on the validity of the finding of this paper without doing that.
Q. Of course. Why not?
A. Why not? Because it doesn't give you the detail of the studies.
Q. No, that's not my question. My question is why didn't you look at that? I mean it's quite an important paper, isn't it?
A. Because quite frankly I didn't have years of my life to spend doing this and I could have looked at all of these but I have a job to do as well. So I looked at the things I thought were important. I read this paper, and I did not have time to go through absolutely everything. We did not get this until a couple of weeks ago.
Q. I think we provided this paper more than a couple of weeks ago. However --
A. Perhaps -- perhaps Mr Heppinstall --
Q. -- if we go to the conclusion here, which is in the abstract and I can tell you that that is the right conclusion, we don't have to go through the paper to find it.
A. I'm sorry, I don't understand how you can define it as the right conclusion --

Q. No, I'm not saying --
MR JUSTICE BLAKE: I think he means the abstract accurately reflects the text of the article. I don't think you were being asked to endorse the whole paper.
DR BUSBY: Well, essentially what this paper does is it collects together -- you agree that it collects together a lot of information, much of which you haven't read or --
A. I think it collects together selective information. It does not contain all of the references of the studies that have been carried out on this. Again, I would refer you to the UNSCEAR 2008.
Q. But 2008 is a long time ago, Professor Thomas.
A. Yes, but I don't think you'll find there's been huge numbers -- these studies take time. If you're going to do them properly you can't quickly turn them round.
Q. I think if you look in this you'll find that there are quite a few studies that have been done since then, but we won't argue the toss.
I just want to come to some conclusion about this and move on.
So the conclusion at the front of this in the abstract:
"We conclude that the current risk model for heritable effects of radiation is unsafe."

Would you agree with that?
A. No.
Q. "The dose response relationship is non-linear with the greatest effects at the lowest doses."
Would you agree with that?
A. No.
Q. "Using Chernobyl data we derive an excess relative risk for all malformations [this is important now] of 1.0 per 10 millisieverts cumulative dose."
A. I don't agree with that. I would actually refer you to the Little paper which I think is far better than this paper for reviewing the real data about teratogenic effects.
Q. We'll go to that eventually but not with you, I think so. That's a doubling dose at 10 millisieverts, that's what that means.
A. If you say so.
Q. No, I'm just saying that's what this says.
A. That's what you state.
Q. And you say that's wrong?
A. I don't think there is the evidence on which that can be based, given what I have read of the papers that have been referred to in this particular article.
Q. And so then it just concludes:
"The safety of the Japanese A bomb epidemiology is

argued to be scientifically and philosophically questionable owing to errors in the choice of control groups, submission of internal exposure effects and assumptions about linear dose response."
Do you agree with that?
A. Again as I said, if you are going to ask me technical details about the LSS methodology, I'm not the person to answer. I'm not an epidemiologist.
Q. Thank you. I think that's all I want to do with that particular paper.
I am now going to move on this because this paper does include within it as part of its review evidence reference to the studies that have been done on the test veterans, one of which has been the subject of some discussion in this arena.
So what I want to do now is take you to SB6/84.
For your information, my Lord, I intend to finish this by twelve o'clock if that would be okay.
MR JUSTICE BLAKE: That would be very helpful.
DR BUSBY: Yes. Now have you got this paper?
A. Yes, I have.
Q. This is a paper written by myself and Mireille de Messieres, which is the second study of the British Nuclear Test Veterans Association. And it was a study which appeared to show an increase in congenital

malformation of about tenfold. Do you accept that that was a correct finding or that that finding was meaningful?
A. Not based on the methodology that was used. You heard the criticism yesterday of the methodology that was used in this. It is not of the same order of the paper that you showed me earlier about the Gulf veterans that was carried out on 15,000 veterans. That was indeed the same methodology but they made efforts to look at the bias that might have occurred because of the methodology they chose to use. This paper does not do that. So I think you have to be very careful how you interpret it and again these are small numbers.
Q. Well, I think that if you look at the abstract at the bottom here, all of this is conceded. It says:
"Whilst caution must be exercised due to structural problems inherent in this study we conclude that the veterans' offspring qualitatively exhibited a prevalence of congenital conditions significantly greater than that of controls and also that of the general population in England."
This was a very large excess. This was a tenfold excess that was found.
So would you say that that might suggest that there might be an effect there?

A. No, because the paper is so poor -- and I'm sorry it's one of your papers and you must regard this as a criticism of you -- the methodology is so poor I would not regard this as scientific evidence.
Q. But as Dr Howard said maybe it's better than nothing?
A. Well, I'm sorry, if we took all science on "maybe it's better than nothing" I think we'd have a real issue with that. You have to do it properly, otherwise you end up with misinformation and that helps nobody.
MR JUSTICE BLAKE: Given this outcome, are you able to assist us on criticisms of the methodology or would you prefer --
A. Yes, this was a survey, my Lord. Again it was a survey sent to -- I can't remember how many it was -- about 2,000 or was it 1,000 personnel?
MR JUSTICE BLAKE: 1,000 questionnaires were posted.
A. Yes, a small response rate, which again should trigger alarm bells. They had 280 that were returned. The number of valid questionnaires returned was 280 out of a total of 1,000 I think that it was sent out to. Although admittedly some of those addresses may not have been correct at the time, but still small.
MR JUSTICE BLAKE: A small response rate. Just headlines.
A. The controls were self-selected, which is not a recognised epidemiological model.

MR JUSTICE BLAKE: Yes?
A. There was no validation of the reports that was given by the individuals responding to the survey.
MR JUSTICE BLAKE: What, medical check-ups?
A. Medical checks-ups, checking with the GP, et cetera. That could have been done. So you don't know whether this was a biased sample again because it's usually those who have an axe to grind that respond to surveys as all of us who lecture know. It's usually the students who didn't like your lecture who respond to the survey of "How was the lecture for you?" So there's an issue there.
Quite frankly, without those validations I think you have to be very careful whether you take this as being representative.
MR JUSTICE BLAKE: Right, thank you.
A. But the other study was quite different in its approach. It was much, much larger, it had the appropriate control selection and they did make a great effort to determine whether the questionnaires that had come back could have some from a biased sample. So there is a distinct difference between the two studies.
MR JUSTICE BLAKE: Right. It's suggested nevertheless that if people do report these health defects that's better than nothing.

A. I disagree with that. I'm afraid I was schooled in scientific method by the Swiss and it is very much that you have to know that the method you are choosing is appropriate to answer the question that you are answering, and if it is not you don't answer the question, because you can end up with a badly designed result which can skew information given to others, particularly when you write reviews and things like that.
MR JUSTICE BLAKE: Right. I think we have this witness' views on --
DR BUSBY: We will continue with this issue of the congenital malformations in the veterans' offspring by going to Professor Howard's supplementary report at SB1/2.9.
A. 2.9?
Q. 2.9, expert witness statement.
MR JUSTICE BLAKE: I think that's what we were told. Yes. Do you have that?
A. Mm-hm.
MR JUSTICE BLAKE: "Expert report, supplementary statement."
DR BUSBY: You were I hope aware that the Tribunal made a third party disclosure order to the University of Dundee --
A. Yes.

Q. -- to obtain the original evidence -- the original questionnaires, all of the questionnaires and in fact they have been supplied also to the Secretary of State.
Now, we reduced those questionnaires to numbers and went over them to see what the rates were relative to the expected numbers in the British population using the EUROCAT database. Have you read this report?
A. I have read this report, yes.
Q. Yes. So you will see that the findings of Professor Howard on the numbers that he saw gave a live birth prevalence rate for congenital anomalies of about 10 per thousand births and he writes:
"These results agreed quite well with the later 2006 study ..."
Which is the one that you just looked at.
This was an earlier sample, a different sample and much larger sample.
A. Sorry, can you -- which one are you reading?
MR JUSTICE BLAKE: I think you've just been directed to the last page of the report at 2.9.
A. Yes.
MR JUSTICE BLAKE: The last paragraph says:
"These results agreed quite well with the later 2006 study by Busby and de Messieres, published in 2012."
Which I gather is what we've just been looking at.

A. Yes, so these are separate questionnaires?
MR JUSTICE BLAKE: Yes.
A. Completely separate?
MR JUSTICE BLAKE: Yes.
DR BUSBY: Much earlier. It was 1998 that these questionnaires were sent out.
MR JUSTICE BLAKE: This was a different sampling --
A. I think we'd have to look at the Rabbitt Roff paper because I take it that the data from that, those survey questions went into the Rabbitt Roff paper. So again there's no detail here about number of questionnaires handed out and response rates and whether there was, you know, any notice taken of a possible bias. So again we'd have to look at the Rabbitt Roff paper to be able to discuss this properly I think.
MR JUSTICE BLAKE: Yes.
DR BUSBY: So --
A. You can't just take numbers like that without proper reference to the methodology.
MR HEPPINSTALL: My Lord will recall Dr Haylock provided a bespoke response to this.
MR JUSTICE BLAKE: Quite. We are getting a lot of value out of this witness and the things that she can tell us about. But it may be best to take this point with Dr Haylock.

DR BUSBY: I think so, my Lord, but I have asked her whether she agrees and she doesn't agree.
A. I can't agree because I haven't got the data in front of me to make up my mind.
MR JUSTICE BLAKE: Can I ask you this question. Let us suppose -- imaginary, and we'll find out whether the imagination and the real have a nodding acquaintance -- you did get a survey of 100, 200, 300 veterans who report congenital defects in their offspring.
A. Yes.
MR JUSTICE BLAKE: And if what they were reporting were accurate, and if, that you have mentioned in your five critiques of the previous survey, you have apparent anomalies, can you not compare with the general expectation of birth rates in the British population? Is at least that comparison --
A. Well, it depends on what your question is, my Lord, at the end of the day. It is are they different from the general population? Or can I assign a causation to their birth defects?
MR JUSTICE BLAKE: Well, the first question. If you are asking for birth defects or specific birth defects -- but it may be birth defects if the informants are not themselves pediatric pathologists or something (which they may not be) -- asking for birth defects --

A. Yes.
MR JUSTICE BLAKE: -- you then get some information.
A. Mm.
MR JUSTICE BLAKE: Is it not then -- is it good science or bad science? But I mean isn't it not some information if you compare that product, with the caveats as to the accuracy of the answer and who you have asked and how you have selected it, but for getting a controlled group now, because don't you then -- can't you use the general stats as a form of control?
A. You'd have to look at the composition of the two groups. So if you were able to statistically prove there was no difference in your population, which might be quite a selective population.
MR JUSTICE BLAKE: Well, it would be --
A. -- because they would be of a certain age and all the rest of it, and probably a certain social class with certain habits, et cetera. To be a fair comparison you would have to select the same group with the identical characteristics from the general statistics, otherwise you could be comparing apples and oranges.
That will work both ways for you, you might have something that is very specific in your group, but you would lose it in the noise of the general sort of needle in a haystack of looking for it in the general

population.
So you have to compare two groups that are the same. So you would ask a statistician to look at the format of your group, age, sex, smoking history, all the rest of it, and then say, "I will extract a group that has the same characteristics in the general population." Then you would have a degree of security of knowing that you were comparing two groups of similar backgrounds.
So you'd have to start there. You can't just generally compare it because you don't know it's an accurate comparison. You could be comparing two groups with very different phenotypes.
MR JUSTICE BLAKE: Right.
DR BUSBY: I think what you've just said -- and correct me if I'm wrong -- the general population has a very different genotype --
A. No, I'm not saying that at all.
Q. I think you just said that.
A. No, I didn't. "Phenotype", not "genotype".
Q. Well, I don't understand how phenotype affects congenital malformations.
A. I think you are completely misunderstanding. When you do a statistical study, to reduce variance in the population what you needed to do is -- if you are looking for a causative effect -- is to compare two

groups that, in every other respect, apart from your causative effect, are very similar. That's what I mean by having the same phenotype. Nothing to do with genes - phenotype.
That means the comparators that you use. So age, sex, race. I mean that's a very common one that we have to control for because, you are right, in different races there are different genetics. So one of the things that you control for is all of those things. If you don't then you are not comparing two groups that are comparable before you start. So if you have a difference in one group you know then that it is due to the cause that you are investigating because you have controlled the other variables.
Q. So in the nuclear worker studies -- and there have been many of them -- that compare the nuclear workers' cancer rates or rates of congenital malformation with the general population and expectation, you would say that those studies were all invalid or questionable, would you?
A. Because they're very large studies those statistical inaccuracies do pale a little, but again it isn't me you should be asking, it's Dr Haylock.
MR JUSTICE BLAKE: I think we are getting the message that if you are really going to go on with these

epidemiological surveys you are going to have to ask an epidemiologist.
DR BUSBY: Yes, that's right, my Lord, I will.
MR JUSTICE BLAKE: Bearing in mind it's now ten to twelve.
DR BUSBY: I will finish by twelve, I promise, even if I have to just stop in mid-sentence.
MR JUSTICE BLAKE: No, no, I am not -- I am asking for an estimate.
DR BUSBY: Or fall over maybe, another possibility, or crash sideways.
These answers are rather doing my head in, I'm afraid.
Okay. Now, can we go to SB7/123. You are familiar with this paper?
A. Yes.
Q. I am sure you are because it's quite a cause celebre amongst these cases. Would you agree that what it shows is that there is an excess chromosome damage, chromosome translocation frequencies, and also they studied chromosome aberrations in some cases.
A. Again, I have questions over the methodology used. Again, it was a small sample size. When we look for chromosome abnormalities, when we study patient samples, we don't just do one part of the cells, we will do multiple sampling to look for regional variance and

things like that and I can't see any statistics on that in this.
So although they looked at a large number of cells, they looked at a relatively small number of individuals. Again, my queries are the same as they were for previous studies, it's a very small sample size, you don't know it's representative of the larger group.
So it says what it says, but whether you can draw conclusions as to the larger group and to other groups of veterans, I'm afraid I would not be happy with drawing that conclusion from this. It's statistically unsound.
Q. So let me put this to you. We have, this morning, looked at papers by Professor Miller in America who works for the military who shows that uranium, maybe chemically, maybe not, but you think chemically, causes chromosome effects or DNA damage in cell cultures. Then we have looked at papers that have shown that the uranium miners have high levels of chromosome damage, statistically significant, but you say a very small sample. We have then looked at Gulf War veterans who have had chromosome analysis carried out, and they have been exposed to uranium, amongst other things, you say. And they have also shown high levels of chromosome damage.

Now we find that other people who are exposed to radiation, anyway, and also certainly to uranium, because that's what the bombs were made of, show chromosome damage.
Do you not think, Professor Thomas, that there may be some background element or cause or thing that might be associated with all of these things that they have in common, exposure to uranium? Do you think that might be a possibility?
A. Firstly, I don't think anybody disputes that uranium is chemically genotoxic; we have lots of evidence on that. We do dispute that it causes cancer in man; we don't have the evidence on that. These are small studies. I'm afraid, I think most people believe that if something is in the scientific literature it's a valid paper. That is not the case, and as good scientists we are trained to look at these papers and say, "Can those conclusions be drawn by that paper?" If they can, you will include it in your analysis; if they cannot, or they are suspect, you will not include it.
That's a process of science that we're all taught from degree level onwards.
Q. Well, let's go back to the process of science briefly. Science is based on a number of philosophical arguments about causation, one of the most important of which is

the canon of agreement which was propounded by John Stuart Mill and the system of logic in I think 1888, but I may be wrong about that, but thereabouts. He would say -- or what it says is that if you see -- if there is a difference between the antecedent of events for an occurrence which you are interested in, if there is an agreement between those, then it could be, or this is evidence, that it is these antecedent events that are the cause of what it is you are looking at or related to that cause.
Would you agree with John Stuart Mill?
A. I would add caveats on that for biological systems. If there are repeated, small samples of a single population that has defined exposure, defined phenotypic characteristics about it and they all point the same way, then that might be evidence. If you take individual studies from different populations done with different methodology, all incredibly small, effectively you are compounding the error.
So no, I do not agree with that, unless you modify what you are saying.
Q. So you are saying if you find the same thing a lot of things places --
A. From totally different studies which are all flawed with the same problem, you could actually be building

something on a false foundation.
Q. But they all same the same thing.
A. Don't care. The answer to that is individually they do not stack up. If you find large studies done in different populations with good scientific method showing all the same things then I would agree with you, but these studies do not support that argument, they are small studies, inherent with statistical error, which do not come from the same population, they have not been subsequently repeated by somebody else on that population. That is one thing that we insist on in medicine, is that things are repeated by somebody else then you know the result is really valid.
Q. Well, in that case I want to take you to SB7/114.
MR JUSTICE BLAKE: So you are leaving this paper behind now, are you?
DR BUSBY: I don't see that I can go any further with this witness on that paper. Is that the right one? No, sorry, we want the New Zealand one.
A. Is it the one you handed out last night?
DR BUSBY: Yes. This is a Rabbitt Roff study, but it's the subset of Rabbitt Roff.
MR HEPPINSTALL: We have it at SB/22.10.
DR RAYNER: It has been put in in the second half of 115, I believe.

DR BUSBY: Yes. New Zealand Naval Frigates. Two Royal New Zealand Naval --
MR JUSTICE BLAKE: I am not sure that there is consensus as to where we are going to put it. SB7 or in SB22?
DR BUSBY: Well, we have it at SB -- all right.
MR JUSTICE BLAKE: Where have you put it?
MS BUSBY: It is continuous with the previous pages in 115, my Lord.
DR BUSBY: Yes. At the back of 115.
MR JUSTICE BLAKE: Could we put it at the back of 115.
DR BUSBY: Yes, that would be reasonable.
So we will recall that we were looking at a study by Rowlands' team, Wahab and Rowlands, that showed a very high level of congenital -- no, what -- of chromosome aberration translocations in a sample of New Zealand test veterans who had been on ships that had been whizzing up and down at the time of the Grapple -- the various Grapple tests, over about a year. So they went to various -- they were in various Grapple tests?
A. Can I just correct you there. They weren't uniformly high, they were distributed. Some had high, some did not have any.
Q. Yes, we are going to come to that one as well.
But let's just start with the fact that some of them were high, on average there were a lot of high levels of

dose, or what they called dose.
So I just want to take you to page 30 --
A. Yes.
Q. -- of this submission, this Rabbitt Roff paper, which was published in the peer review literature. I want to look at conceptions here.
A. Mm-hm.
Q. So there were 443 conceptions reported for the 235 men, and of these 22 per cent were miscarriages, 16 per cent were still born and 2 foetuses were aborted. Do you think that would be normal in a population of that size?
A. I don't know. Reproductive numbers are not in the forefront of my brain, I am afraid I am too old for that.
Q. It seems rather high, don't you think?
A. Unless we have a control data from New Zealand, I think it would be difficult to know whether those were low or high. Again, I hate to say this and I hate to keep repeating myself, this is a self-reported questionnaire with only about 45 per cent response rate. You don't know this was unbiased, and they have made absolutely no attempt to address any bias that might be there or even noted there will be a bias there.
Q. Let's canter on. The second sentence:
"Of these 117 prenatal and still born deaths a large

number were reported as severely deformed."
What would you comment on that?
A. I can't comment on it because I don't have the data to be able to compare it with to tell you whether that is unusual.
Q. So you think maybe that would be usual at 26.4 result of conceptions did not result in --
A. Again, they are self-reported --
MR JUSTICE BLAKE: Okay, I think you've made the point. She's not going to comment upon the conclusions because she doesn't have enough information --
A. And the methodology is flawed, my Lord.
DR BUSBY: I think what I am asking you to say is whether you think that the background data from New Zealand, if you like the control group, would have such high levels of --
A. The answer is I don't know, I don't have those statistics and I am not going to hypothesise without the proper evidence. That would be wrong of me.
Q. Just as an ordinary person.
A. I'm not prepared to speculate. I'm not here to speculate.
MR JUSTICE BLAKE: You have her answer.
DR BUSBY: I think that's as far as I can go with that, my Lord.

Well, by my watch it's 11.59 and 45 seconds and so, actually, I have finished my cross-examination, my Lord.
MR JUSTICE BLAKE: All right.
DR BUSBY: You will be glad to hear.
MR JUSTICE BLAKE: Thank you very much. Thank you Professor Thomas.
A. Thank you.

Questions from the Tribunal

MR JUSTICE BLAKE: Mr Heppinstall, just before you re-examine, Dr Rayner would like to ask a question. It may be helpful for you to have the answer before you re-examine.
DR RAYNER: Can we go back to SB7, I'm afraid.
A. Yes, I have it in front of me.
DR RAYNER: 123. So I think you were in court yesterday when these studies were discussed?
A. Hang on a second. I'll get there now. 123, yes?
DR RAYNER: Yes. I am not going to ask you about the studies first of all, I just want to ask your general opinion on the validity of the mFISH technique and its application.
A. Yes, not good, I think. I mean, there's been a lot of discussion about looking at chromosomal aberrations using these type of techniques. I don't think we would use these any morning going into the future, we turn to

genome sequencing and things like that, because we can do it.

These tests are -- I mean, usually you have to have quite a high impact on your cells. I think some of these were done a very long while after the actual exposure. I am interested -- I mean, that suggests to me that, if these are genuine, then those must be in stem cells because you will have lost your circulating lymphocytes during the 50-year period several times over. I find it very strange that these results are valid given the -- and due to radiation exposure, they could be due to many other things -- and due to radiation exposure after a 50-year gap.

MR JUSTICE BLAKE: I know that my colleague was asking the question, and I am not presuming to take over her question, but I just wanted to break down your answer.
A. Sure, yes.
MR JUSTICE BLAKE: MFISH. You first started to say not a good technology for assessing.
A. Yes. It's not sensitive.
MR JUSTICE BLAKE: Enough. Or sensitive.
A. Yes.
MR JUSTICE BLAKE: And you prefer to do what?
A. We'd now do whole genome sequencing. Because of the human genome having been sequenced we can do that fairly

cheaply. Well, a thousand dollars.
MR JUSTICE BLAKE: Okay. I want to come on to the second point you've made, but I want to see whether it's an aspect of the first or a freestanding point.

The gap between the event --
A. Yes.
MR JUSTICE BLAKE: -- whose causal significance is being debated, and the use of the mFISH --
A. Yes.
MR JUSTICE BLAKE: -- I'll stand corrected but I think it was about 45 years later?
A. Yes, it's a very long time period. Your blood cells turn over fairly rapidly, my Lord.
MR JUSTICE BLAKE: Now, does the use of the mFISH, despite the fact that you can now go to human genome sequencing, but assuming -- does that diminish as mFISH after 45 years, or it's just the fact it's 45 years?
A. It's just it's 45 years --
MR JUSTICE BLAKE: So it's not a defect of the mFISH --
A. Yes. It may be, of course, by something else in those 45 years that you haven't taken account of, because you would lose an awful lot of these abnormalities as your cells die and your lymphocytes do die over time.
MR JUSTICE BLAKE: So the passage of time rather than the use of mFISH diminishes the security of the conclusions

you can make from the report?
A. Yes. It's fallen out of use because everybody knows it's a difficult technology that actually isn't very sensitive so a lot of people are not using it.
MR JUSTICE BLAKE: That's a freestanding point from 40 years, is it?
A. Yes.
MR JUSTICE BLAKE: You have two points, I've called them 1 and 2 in my notes, and I'm not sure that you have any more coming but those are the two points you've made.
A. Yes. I mean, normally this sort of test is used fairly soon after exposure to a substance.
MR JUSTICE BLAKE: Yes, I get that, but that is simply because the longer you wait the more problematic the results are going to be, is it?
A. Yes.
MR JUSTICE BLAKE: If we break down your second point, 45 years, I have (a) -- now going to letters rather than numbers -- that some of the hypothetically-damaged cells will have died off?
A. Yes.
MR JUSTICE BLAKE: (b) other events might have happened in the data subject's life?
A. Yes. One of those would be obviously whether they've been exposed to other radiation sources as part of their

diagnostic radiology or chemotherapeutic agents, et cetera.
MR JUSTICE BLAKE: Well, maybe they've taken miners in Chernobyl with uranium --
A. Yes.
MR JUSTICE BLAKE: -- or something.
Anything else you want to comment upon?
A. No, I think that really addresses the questions.
DR RAYNER: So, moving on from that, in the report that follows the published paper, so if you turn to page 40 of the report, still in the same tab.
A. Yes.
DR RAYNER: Do you have that?
A. Yes, I've got it.
DR RAYNER: Okay. So in the second paragraph down it talks about the results found in French Polynesians with thyroid cancer, which hopefully is definitely your --
A. Yes, I don't actually know that paper.
DR RAYNER: Well, that was my next question: do you know that paper?
A. No, I don't know that paper, I'd have to look it up.
DR RAYNER: Right. Okay.
Because this basically talks about the high level of dicentric chromosomes, which then the conclusion of that is that this is specific to radiation. What do you have

to say about that?
A. That has always been the perceived wisdom that dicentrics -- which actually interestingly weren't elevated in the paper itself -- is a response to radiation, yes. And translocations do occur, but they occur at a lower frequency.
DR RAYNER: Right. Thank you. I don't have any more questions thank you.
MR JUSTICE BLAKE: Thank you.
Re-examination by MR HEPPINSTALL
MR HEPPINSTALL: Would you turn to SB4, and we are going to start at 29.
A. 29?
Q. 29, yes.
A. Okay, got it.
Q. Can you tell the Tribunal what we are looking at, please?
A. We are looking at a letter that was written in response to the paper by Dr Tsuda that was published in epidemiology earlier on this year.
Q. Is that the paper that we looked at earlier with Dr Busby?
A. Yes.
Q. And this is a letter from Sadao Suzuki?
A. Yes, yes, there's two letters -- yes, that one.

Q. Then there's another one over the page from Yoshisada Shibata?
A. Yes.
Q. Then another one from Richard Wakeford and a number of other authors; is that right?
A. Yes, that's right.
Q. What is the content of the letters?
A. That they make the point that the Tsuda paper was not a well-performed study and that his conclusions were invalid, in a nutshell.
Q. I think there is then a number of tabs, 30, 31, 32, 34 and 35. Ignore 34. It's 29, 30, 31, 32 and then there's another letter at 35.
A. Yes.
Q. Are they all similar letters?
A. They are all similar because it caused quite an outcry when it was published, and a lot of questions about why it was published in the journal and who reviewed it.
Q. Is that what you were referring to earlier?
A. Yes.
Q. Tab 12, please. Page 7 of 51. We've looked at this earlier in the proceedings. This is from the US Agency for Toxic Substances and Disease Registry, "Case Studies in Environmental Medicine". This is a paper on uranium toxicity.

At page 51 can you see where it says "three types of natural uranium"? 7 of 51 is on the bottom-right hand --
A. Yes.
Q. -- and under "Definitions" we have "Where found", "Milling and Radioactive Wastes" and "Three Types of Natural Uranium". Do you see that?
A. Yes.
Q. It says:
"Natural uranium is a mixture of three types ... U234, U235 and U238..."
Do you agree with that?
A. Yes.
Q. "All three isotopes behave [in the same way] chemically, so any combination of the three would have the same chemical effect on a person's health."
Do you agree with that?
A. Yes.
Q. "But they are different radioactive materials with different radioactive properties."
Do you agree with that?
A. Yes. So I made a mistake earlier.
Q. What mistake did you take earlier?
A. I made a mistake and said that one of them was stable, I misremembered that and that is a very silly mistake to

have made. But they are radioactive, but with different --
MR JUSTICE BLAKE: Radioactive properties.
A. Yes, exactly.
MR HEPPINSTALL: As you go down that page it says:
"Radioactive elements are those that undergo spontaneous transformation in which energy is released ... either in the form of particles, such as alpha or beta ... or electromagnetic radiation with energies sufficient to cause ionization, such as gamma or X-rays."
Do you agree with that?
A. Yes.
Q. "This transformation or decay results in the formation of different elements, some of which may themselves be radioactive, in which case they will also decay."
Do you agree with that?
A. Yes.
Q. In the next paragraph:
"When an atom of any of these uranium isotopes decays, it emits an alpha particle ... and transforms into a radioactive isotope or another element."
Do you agree with that?
A. Yes.
Q. "The process continues through a series of radionuclides

until it reaches a stable, non-radioactive isotope of lead."
Yes?
A. That's correct.
Q. The next paragraph:
"In addition, each isotope has a different radiological half-life or the amount of time it takes for one-half of the atoms of the radionuclide to transform."
Do you agree with that?
A. Yes.
Q. "U234 has the shortest half life and is, therefore, the most radioactive, followed by [I think they mean in order] U-235 and U238."
Do you agree with that?
A. Yes.
MR JUSTICE BLAKE: I thought for a dreadful moment they were footnotes 235 and 238, but I was pleased to realise they were in fact references to the items.
A. Yes.
MR HEPPINSTALL: Now, in SB22/6 --
A. Yes.
Q. -- are these the papers you were referring to in table 1 of the Busby, Feuerhake, Flugbail paper?
A. Yes.

Q. So my Lord will remember that it is my promise to go back to the --
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: These are the papers from table 1, which we have; is that right?
A. Correct.
MR HEPPINSTALL: Now, I hopefully have them in the same order as you.
A. Starting with the Turkish paper.
MR HEPPINSTALL: The Turkish paper, which is Akar; is that right?
A. Yes.
Q. Do you want to make any comments about this paper?
A. Again, they did not control or actually make any statement about alcohol consumption -- which may be not a problem in Turkey given its religious status, but which we know affects neural tube defects -- but they didn't take any account of folate deficiency that might occur in that particular population. So without that detail you cannot -- you are just associating, you are not defining cause.
Q. Is there any evidence about dose in that --
A. Absolutely none.
Q. If we turn over we get to, stretching my Ukrainian or Russian pronunciation --

A. "Feshchenko".
Q. Thank you:
"Congenital malformations among newborns and developmental abnormalities among human embryos in Belarus after Chernobyl accident".
Do you have any comment to make about this paper?
A. Again, the the criticisms. But they also -- here they have used the dose -- they have a supposed dose rather than measured a dose or reconstructed a dose so you would know what the individual dose was of the participants. They've just simply related it to the ground level dose, which is not really sufficient if you want to pin down a causation to radiation because the way you live, whether you stay indoors, whether you are outdoors, and the food you eat, will contribute to your dose.
So with no reconstruction of dose in this, again you cannot really do more than just say, "Oh look, interesting", you can't prove anything.
Q. Next in my --
A. Again no folate and all the rest of it.
Q. Next in my compilation is a paper by Wolfgang Hoffmann?
A. Yes.
Q. "Fallout from the Chernobyl Nuclear Disaster and Congenital Malformations in Europe".

Can you turn please to page 482.
A. 482. Yes.
Q. There you will find the conclusions. Could you read out the conclusion to the Tribunal -- the first sentence of the conclusion, please?
A. Yes:
"Whether radioactive fallout from the Chernobyl disaster has cause health effects in Europe cannot be answered with confidence at this point in time. Positive findings of congenital malformations and chromosome aberrations deserve thorough scientific investigation. Health effects cannot be readily dismissed on grounds of established risk co-efficients. Instead, their confirmation would question the prevailing paradigm of a linear dose response curve for small doses of ionising radiation."
So basically he is saying, "There is evidence, but I can't work out what it means at the moment." This is the review paper again, rather than having substantial information of first hand data.
Q. The next paper is I think by Kulakov and others, "Female reproductive function in areas affected by radiation after the Chernobyl power station accident".
If you again go to the conclusion, please, and look at the third paragraph of the conclusion. Do you have

any comment to make about that?
A. Starting, "It is difficult to interpret"?
Q. Yes.
A. Yes. Again, they are being honest and they are saying, "We can't really interpret this data and there's no definite information concerning the effects of minor dose of radiation on humans." So they are being quite honest that they can't actually interpret the data that they've got and say it is due to radiation.
MR JUSTICE BLAKE: One of us -- Dr Rayner has these papers, so that's good. I am not interrupting --
MR HEPPINSTALL: I am deliberately reading onto the transcript so that you can see --
MR JUSTICE BLAKE: As it happens, we don't.
MR HEPPINSTALL: Very well.
Then the next one is a paper by Lazjuk, Belarus Institute for Hereditary Diseases, Minsk, "Changes in registered congenital anomalies in the Republic of Belarus after the Chernobyl accident".
Do you have any comment to make about this paper?
A. Again, it's similar comments to the ones before. They have the same flaws. Again, they're using ground measurements of radioactivity to infer actual dose to human beings without taking the trouble to reconstruct the dose and understand the different habitus that

affects the dose actually received by people.
Q. Then the next is Petrova, "Morbidity in a large cohort study of children born to mothers exposed to radiation from Chernobyl. If you turn to page 149 you will see the discussion. If you have a look at the second paragraph and provide your comment on that.
A. 149. Sorry, where did you say?
Q. 149, discussion section.
A. Sorry, let me just read this for a second, because there's an important thing in the abstract as well.
Q. Yes.
A. The second paragraph simply says:
"Nevertheless, caution must be emphasised when interpreting these results."
So they are being quite honest.
"Other environmental factors, such as exposure to pesticides among mothers in the cohort study may have confounded interpretation in the data. Other confounders such as viral infections, industrial exposure, cigarette smoking and inherent genetic susceptibility may also be causally related to disease or abnormalities in laboratory tests."
They actually indicate in the abstract that they found decreased levels of copper and zinc from heavily contaminated Oblast findings that may be related more to

inadequate nutrition, which we know affects perinatal health, than to radiation exposure. And they state that in the abstract. So the authors are being honest about their results.
Q. We are almost there, the last one is Wertekecki, "Blastopathies and microcephaly in a Chernobyl impacted region of Ukraine". Do you have any comments to make about this paper?
A. Again, the same problems arise in that they do not have information on folates deficiency, and in fact I think there was another paper by Dr Holt in The Lancet who looked at this paper, he is an expert in his field, and said you cannot draw conclusions that this was due to radiation as there are so many other confounders that would be present in that population. The largest of those being the folate.
Q. Can you turn back now, please, to SB6/89.
MR JUSTICE BLAKE: Are we leaving the topic?
MR HEPPINSTALL: You can leave SB22 behind now, we are on the same topic.
MR JUSTICE BLAKE: The same topic. Right. I might have a supplementary about Professor Hoffmann, but without having read it --
MR HEPPINSTALL: If you wish to deal with it now, my Lord.
MR JUSTICE BLAKE: Okay. Just in case -- so you don't have

to take it out again -- as you may have heard -- well, two of us don't actually have these papers -- but I've just been looking at the passage that was put to you about the Hoffmann conclusions at 482. Do you want to just pick that out again. It's tab 6, it's the third of the three pages.

A. Yes, let me find the right paper.

MR JUSTICE BLAKE: Hoffmann, Fallout. The third page.

A. Got it.

MR JUSTICE BLAKE: Yes. So, now you're in the paper, go to 482.

A. Yes.

MR JUSTICE BLAKE: You've been taken to the conclusions just before you get the references.

A. Yes.

MR JUSTICE BLAKE: Right. The first sentence shows what it shows. I don't need to ask you about that.

A. Mm-hm.

MR JUSTICE BLAKE: Cannot be stated with confidence.

The second records positive findings.

A. Mm-hm.

MR JUSTICE BLAKE: Deserving thorough scientific investigation. You don't have any problems with that, I take it?

A. If they are indeed positive. I mean, that is the issue.

He cites them as positive because it is in his interest -- use of English is always very interesting in these papers, most people are looking for more money to carry on their studies when they write this, so you have to bear that in mind -- but if these were positive, and I totally agree with him, if these were positive, from good studies, then they should be investigated properly and then we would have a scientific basis on which to know whether it is true or not.

MR JUSTICE BLAKE: "Health effects cannot be readily dismissed on grounds of established risk co-efficients."

A. I think you'll find that this gentleman has a particular view on risk co-efficients.

MR JUSTICE BLAKE: What your view?

A. I think we have to go on scientific evidence, and our risk co-efficients are based on good scientific papers, not rubbish. So I think, if you are using a risk coefficient that is scientifically rigorous, it's been examined, it's been actually supported in a number of recent studies --

MR JUSTICE BLAKE: I appreciate that, but supposing you can -- you can have the seed germ of an idea which might result in a where do you start is going to be the argument.

A. Yes, but you'd have to look at it with the same

scientific rigour at any other model that you were going to put forward.

MR JUSTICE BLAKE: All right. Then it's the last one:

"Instead, their confirmation would question the prevailing paradigm of linear dose-response curve for small doses of ionizing radiation..."

Now, I have all the stuff you've given us, but if these results have been confirmed would they have that effect?

A. If they were confirmed, if, and there's -- "if" is the big --

MR JUSTICE BLAKE: I am not trying to slip you into agreeing with a proposition, but I just want to see whether the internal logic follows.

A. The internal logic is absolutely fine, but it's the basis on which you are determining your next step that I am questioning.

MR JUSTICE BLAKE: Although you've been through a lot of papers, do we know whether there has been any confirmation?

A. No. Actually, my Lord, there has not.

MR JUSTICE BLAKE: Has there been any study --

A. There have been studies -- again, I would refer you to the UNSCEAR annex, which will have chapter and verse on that.

MR JUSTICE BLAKE: This is 2000 --

A. Yes, and particularly Mark Little's paper as well, the other one that we were given recently, that reviews all of the literature in a very unbiased fashion.

MR JUSTICE BLAKE: So, even if internal logic saying something has emerged, it needs further studies, if the result of the study is to confirm the finding, it might have this effect, but that's okay. There's a bit of reasoning --

A. That's okay with the reasoning, but you would have to go and get a grant from a body who would have to look at the science and say is it reasonable.

MR JUSTICE BLAKE: Just to understand how much we -- what your more detail --

A. I don't have any problem with what he states there, it's whether they are genuine.

MR JUSTICE BLAKE: Got it. Sorry to interrupt you. Carry on.

MR HEPPINSTALL: Not at all, my Lord.

SB6/89, this is back to the paper from which the references we were just looking at are taken. SB6/89. Yes. Which is the Schmitz-Feuerhake, Busby, Pflugbeil.

A. Yes.

Q. In the conclusion section of the abstract you were taken to a sentence:

"Using Chernobyl data we derive an excess relative risk for all malformations of 1.0 per 10 millisieverts cumulative dose."

Do agree that's what that says?

A. I agree that's what that says.

Q. Can you turn to table 1, please. Now, you've not looked at all of these references, but, you know, we've looked at Hoffmann, Lazjuk Kulakov, Akar, Wertekecki, Petrova, et cetera.

Now, you see here that in this table there's a column which is marked "Estimated doses"?

A. Yes.

Q. Did you see any evidence of those in those papers?

A. No, I didn't.

Q. Do you see that there are some footnotes, for example Hoffmann, there's a tiny footnote B against 0.1 to 0.5 millisieverts? Can you turn, please, to page 5.

A. Yes.

Q. Can you see under the table, footnote B, and can you read that out, please?

A. The whole of it?

Q. No, no, it's hard to see but there's a little a and then --

A. Oh, yes.

Q. -- you see it says, "These dose are taken from figures 1

and 3"?

A. "These doses are taken from figures 1 and 3 of Savchenko and represent the mean countrywide first year (ICRP) committed effective dose."

Q. Now, if you look at all the doses in table 1, I think the vast majority of them have a little b against them. So are we to presume that what's happened -- well, you tell me what you think --

A. Basically, I suspect what they've done, without going back to check the Savchenko paper, is they have assumed a dose from the dose that has been taken from the ground dose.

Q. So these doses don't come from the actual papers cited, they've all been taken from another source?

A. Yes. And I doubt, actually, in the individual papers, whether you would have had sufficient data to know where all of these different populations were resident. So I think that's a very insecure thing to have done.

Q. Well, my last question is do you think that that's a safe or an unsafe basis from which you can draw the conclusion in the abstract, "Using Chernobyl data we derive an excess relative risk for all malformations of 1.0 per 10 millisievert cumulative dose"?

A. I think it is extremely unsafe.

MR HEPPINSTALL: No further questions.

MR JUSTICE BLAKE: Right. That completes your evidence. Thank you very much for coming and you can now go.

THE WITNESS: Thank you.

(The witness withdrew)

MR HEPPINSTALL: My Lord, I wonder if we might have an earlier than usual lunchtime adjournment?

MR JUSTICE BLAKE: Yes, we can.

MR HEPPINSTALL: I am most grateful.

MR JUSTICE BLAKE: I am anxious that -- assuming there is a good degree of confidence about the progress we're making -- we finish this afternoon at some point between 3.30 and 4.00.

MR HEPPINSTALL: I am in other's hands.

MR TER HAAR: I hadn't expected to start Mr Hallard today. I have plenty to ask him. So I would be very happy to rise at 3.30 today. Apart from the fact that it's Friday.

MR JUSTICE BLAKE: Yes, well there are other things that I have to keep my eye on before I go home, so it's not that I'll be on -- you know.

MR TER HAAR: So I would be happy to make a start and also happy to have that bit of extra leeway.

THE WITNESS: I just wanted to warn somebody. I've taken two things out of the bundle which need replacing.

MR JUSTICE BLAKE: Unless you want to hear about how we are

going to organise this afternoon, do head back, I am sure you have other things to do.

THE WITNESS: Thank you.

MR JUSTICE BLAKE: Yes. Do you want to start at 2.00 or do you need a little bit more time?

MR TER HAAR: I don't need any more time than that, no. Half past one or two, as suits the Tribunal.

MR HEPPINSTALL: I was seeking the usual hour. If Mr ter Haar would like more.

MR JUSTICE BLAKE: Okay. If we rise now and we come back at half past one and then we can break by 3.30. Is that going to work?

MR TER HAAR: It seems to me it will.

MR JUSTICE BLAKE: Yes. We can give our stenographers a break some time halfway through that period.

(12.30 pm)

(The short adjournment)

(1.30 pm)

MR HEPPINSTALL: My Lord, before I call Mr Hallard I should like to draw something to the Tribunal's attention. Professor Thomas, before giving her evidence earlier in the month on 20 May received some e-mails that she drew to the Secretary of State's attention. She didn't want us to pass those on to the Tribunal. However, she did receive a further e-mail on 17 June, i.e. today, at

9.40, just before she was due to give her evidence, which she was concerned about and was upset about. She would like me to draw those your attention. We have copies for you.
MR JUSTICE BLAKE: Yes. (Handed).
MR HEPPINSTALL: Like all e-mails they are in reverse order so you will have to go right to the back to see the chain. The first e-mail was from a Major Alan Batchelor to Professor Thomas, copying in Dr Busby, a Mr David Whyte, who I believe is an appellant in the NTV group of appeals, not this group but the wider group, and also Mr Andrew Ades.
The second e-mail is from Dennis Hayden to the same circulation list.
Then an e-mail that particularly upset Professor Thomas before she gave evidence this morning is one circulated to her junior staff just before she came into court this morning.
Now, the Secretary of State, because we do not know precisely who these people are, nor the precise details of the matters that are set out in the e-mail, makes no allegation or point about these e-mails save that (1) Professor Thomas would like the Tribunal to know she was particularly personally upset by the e-mail she received immediately before she gave evidence this morning. She

asked you to note the people who are copied into that e-mail. We have met some of the characters before in the proceedings. Mr Paul Dorfman was involved in the CERRIE report. Mr Richard Bramhall you've heard from in evidence, and Dr Chris Busby is also listed in that circulated list. As I say, she was particularly upset personally this morning because it is addressed to a junior member of her staff.
That's the first point.
The second point, my Lord, is that the Secretary of State will take action, whether is referring matters to the Attorney-General or in the Divisional Court in the aid of the execution of this jurisdiction, because this jurisdiction has no contempt of court --
MR JUSTICE BLAKE: We don't have contempt powers, no. The most I could do would be to refer this correspondence to the Attorney-General.
MR HEPPINSTALL: Indeed, or we could start a civil claim for contempt in the civil court. However, we're not making an allegation or taking any action in respect of these e-mails. But if there is any escalation or future e-mails which do cross the line into witness intimidation of any witness, whether it be the Secretary of State's or any other party's witness before

this Tribunal, action will be taken.
MR JUSTICE BLAKE: Yes, thank you. I have only just glanced at it. Obviously in the Internet age --
MR HEPPINSTALL: Indeed, my Lord.
MR JUSTICE BLAKE: -- people's e-mails and social media, if one is foolish enough to have one, for which I can speak for the generation that doesn't, can be polluted by trolls. But when it comes to adverse comments to a witness before a court or a tribunal, who is doing their best, then criticisms which are intemperate and personal and intimidatory are capable of amounting to a contempt.
MR HEPPINSTALL: Indeed, my Lord.
MR JUSTICE BLAKE: I am glad to know that you will refer these matters for appropriate consideration. I would seek to protect any witness of any side appearing before this Tribunal who was the subject of contumacious comment, but I don't need to.
MR HEPPINSTALL: I am grateful, my Lord.
I now call Mr Hallard, please.
MR RICHARD HALLARD (sworn)
Examination-in-chief by MR HALLARD
MR JUSTICE BLAKE: Right. I think we are going to be a couple of hours this afternoon. We are going to up stumps around about 3.30. Do you want to stand or do

you prefer to sit?
A. I'll start standing, my Lord, and I'll probably sit later on if that's okay.
MR JUSTICE BLAKE: Yes, please, whatever makes you more comfortable in order to give your evidence.
A. Thank you.
MR JUSTICE BLAKE: Just give me a moment.
MR HEPPINSTALL: If you could pull out SB2, please. Tab 2.14, please. Is that your first report to this Tribunal?
A. Yes, it is.
Q. If you turn to the last page, page 285, you there signed the expert's statement of truth. Is that still the case today?
A. Yes.
Q. And you then answered some questions and produced a supplementary report on 5 May 2016 which I think is at 2.15; is that right?
A. It is.
Q. And then the report where you were answering questions is at 2.17; is that right?
A. Yes, it is.
Q. It is. Then you followed that up with a further supplementary report of 5 May and that's what's at 2.15.
A. Yes, that's correct.

MR HEPPINSTALL: If those three reports could stand as this witness' evidence-in-chief, my Lord, I have no further questions.
MR JUSTICE BLAKE: Thank you.
Cross-examination by MR TER HAAR
MR JUSTICE BLAKE: Yes.
MR TER HAAR: Mr Hallard, good afternoon. I think you've been sitting through the whole or most of the proceedings?
A. Most of the proceedings.
Q. Have you given evidence before or is this your first time?
A. It's my first time.
Q. Could we just look at your CV which we have in bundle SB2 at tab 2.14 at page 283.
Part of what I want to do with you is just to try to make sure that we can understand what your professional experience is and how that fits in with some of the other experts in this case. There's one thing which undoubtedly is clear; that you have very considerable experience in the nuclear industry because that has been the whole of your working life?
A. Most of it, yes.
Q. Can we start with the second page of your CV, that's page 284. Right at the bottom: Durham University, BSc

with honours in applied physics?
A. Yes.
Q. Was that specifically in medical or health physics?
A. No, it wasn't. It was in general physics and electronics, that kind of thing, so it was more general physics.
Q. Because medical physics, for example, is a specialist subset of natural sciences in itself, isn't it?
A. It is, I believe, yes.
Q. And the sort of specialties you find within the world of medical physics are people for example who are members of world watchdog committees, that sort of thing; you agree with that?
A. Erm --
Q. That's one area of activity carried out by medical physicists?
A. I would -- I believe so. I don't think you would have to come from that background if that answers your question. But that would certainly be one source of people from that area.
Q. I was thinking it is more the other way round. One of the activities which medical physicists carry out is assisting on world watchdog committees?
A. I don't think I know the answer to that question. I think it's probably true but I don't know the answer

to that question.
Q. I'm a little surprised because I would have thought as we go through it one of the things you have to do for the various functions you've been carrying out over the years is to take on board received wisdom as to concerns about in particular occupational hazards which come from such bodies as world watchdog committees?
A. Oh yes, that's certainly true. It's just the link between would -- I think you were implying that people from a medical physics background would go into watchdog bodies and I think that's probably true but I've never actually looked at that link, but certainly I'll look at the output from watchdog bodies.
Q. You yourself have never sat on a watchdog committee or anything of that sort, have you, according to your CV?
A. No, I think in the context that you are referring to there, no, I don't think so. I have been involved with committees, so working with the Health and Safety Executive, for example, to assist in providing feedback to the draft European Union directive on the basic safety standards. But that I don't think is what you are referring to by a watchdog body.
Q. No, it's not. The reason I ask is this. Watchdog committees exist for most of the major industries of the world, don't they?

A. Yes.
Q. Including obviously the nuclear industry and other -- I say nuclear industry, but other bodies concerned with the use of radioactive materials?
A. Yes.
Q. And what is important with a watchdog committee, exactly as the name suggests, is to take cognisance of hypotheses which are coming forward in order to see whether they may be an indicator of the need to revise consensus opinion. Would you agree with that?
A. Yes, that would be one of their roles.
Q. Now, I'll come back to your CV in a moment, but if we just take your lifetime in the nuclear industry, it goes back 40 or 50 years --
A. 40 -- about 40 years.
Q. During that time there's been enormous progress on many interrelated fields. For example we know more about DNA than we did 40 years ago?
A. Yes.
Q. We know more about damage, potential damage to DNA than we did 40 years ago. You would agree those are examples of the sort of general progress that's made in science which has implications for the nuclear industry?
A. Yes.
Q. What I suggest is that the sort of watchdog committees

of the sort I mentioned are looking to see if some scientist comes up with a plausible hypothesis which might need further investigation. It may not yet be proved but it's the first seeds of an idea which grows and you're familiar with that sort of process?

A. Yes.

Q. How in your experience does a body such as Sellafield, with which you've been concerned, take on board the fact that perhaps a scientist in Australia has identified what may be a concern that has not yet been carried through the full process of research, controls, et cetera, in order to see whether the concern is a genuine one?

A. You ask specifically about how would -- well, Sellafield you mentioned but say another site, any site --

Q. I mentioned Sellafield because that's where you've been.

A. Yes.

Q. But I'm not limited to that. I'm really looking at how the nuclear industry takes on board the fact that somebody may have an idea, the implications of which may be enormously important for the health of the workforce. How does that work in practice?

A. The principal way it would work would be through legislation. So if a new idea comes forward that would then be considered by the -- well, by Public Health

England now. Formerly that would have been the Health Protection Agency and then before that it would have been the National Radiological Protection Board.

I merely mention that because some of those acronyms, NRPB, for example, have appeared in some of the past papers. So that as an organisation would look at those ideas, analyse them technically. They would then come forward with recommendations. It would also be -- and principally actually it would be looked at through the ICRP, the International Commission on Radiological Protection, which I think is an acronym, ICRP, that we've also heard a number of times. They would look at the papers, they would look at the technical background to the work which had been done. That would then go forward in the form of recommendations from the ICRP which would be evaluated by Public Health England, amongst others. They would be evaluated by the International Atomic Energy Agency.

Ultimately, after some period, that would then come through in the form of what are called basic safety standards, both from the IAEA and also the European Union draft directive, based on recommendations which had come from the ICRP. Those would then come forward in the form of national legislation which would ultimately be implemented in the UK by legislation, by

regulations called the ionising radiations regulations.

Those current regulations were issued -- they are the ionising radiation regulations 1999 which were issued at the start of the year 2000. There will be or there are likely to be another set of ionising radiation regulations in the next few years which will implement the recommendations from the last set of major recommendations from ICRP which was ICRP/103.

That's what it's called, the document. The annals of the ICRP, volume 103.

Q. So obviously we heard from Professor Thomas -- and it makes sense, we've seen it from documents -- that running something like a power station, as a manager you need to have really levels, you need to have a threshold, you need to say "This is safe, this is unsafe" and you balance the risks against what has to be done?

A. Can I qualify that slightly? There are three principles in ICRP which were established several decades ago and the three principles are known as justification, optimisation and limitation. Sorry, this I think is relevant to your question.

Justification means that any practice, that any operation if you like which involves exposure to ionising radiation must be justified, so that the

benefit must exceed the detriment, the cost, if you like, but that's the cost in its broadest terms, in terms of health, financial cost and other costs at the time.

The second, which is the point I really want to make in answer to your question, is optimisation. Optimisation is something which I think will be very familiar to the court. The principle of optimisation is that radiation levels must be reduced to as low as reasonably practicable, ALARC.

And the third, which I'll just complete, but then I'll go back to optimisation, and the third principle, limitation, says: regardless of the other two, the dose of radiation must be less than certain numbers.

I'm sorry, I wasn't sure if this is what you meant but I did infer from your question that perhaps you were thinking about the dose limits.

The optimisation principle, if I may just finish that, says that regardless of the limits, the exposure to radiation must be reduced to a level which is as low as reasonably practicable. And that is probably -- that principle has probably had more to do with reducing the radiation doses in both medicine and the nuclear industry and academia than any other single factor, more so than limits.

MR JUSTICE BLAKE: So an absolute limit is part of it but it's not the whole story?
A. Exactly.
MR TER HAAR: It's a very simple point. For certain purposes you set and have regard to thresholds? There may be other qualifications but in broad terms you would set and have regard to thresholds, yes?
A. Limits. I am not quite sure what you mean by "threshold" in that context.
MR JUSTICE BLAKE: What's the difference between a threshold and a limit?
MR TER HAAR: I don't think there is, but let's put it this way. For certain purposes you say: "I do not want my workforce to be exposed to more than a set figure of radiation"?
A. Yes, that's correct.
Q. I'm not on a sophisticated scientific basis. I'm trying to just make a very, very general point at the moment.
A. It's just that the term "threshold" tends to mean something else in radiation protection and I just I think misunderstood your question.
Q. I'm not using specialist language at the moment.
A. I understand.
Q. The process which you describe through legislation is one which may result in what I call a threshold, in the

broad sense I've just used it, being reduced; you agree?
A. Yes.
Q. And I think what you described is what can be a very lengthy period from my hypothetical Australian scientist coming up with a hypothesis to a consensus being reached scientifically, leading to the ICRP agreeing with that consensus, leading to the national legislation. That can be a very substantial gap in time, can't it?
A. It can. I think if there are particular concerns that are raised, the process will tend to work more quickly.
Can I give you an example of something which has occurred in the past relatively small number of years.
The current limit for the eye lens from memory is 150 millisieverts. There has been particularly one paper, and I think it may now be supported by more than that, which has indicated that that level may now not be appropriate. The risk to the lens of the eye is a cataract and the paper has proposed that cataracts can occur at lower doses. As a result of that there is a recommendation which has come out of ICRP which has only come out in the past small number of years, I think, which has now, if my memory serves me correctly, been incorporated. It was introduced into the draft basic safety standard and is now incorporated into the safety standards. So that the basic safety

standard now, the European basic safety standard, if my memory serves me correctly, does now incorporate the lower limit which is 20 millisieverts for the eye lens. So that would be the limit that would go forward into the legislation.
Implementation of that will take a little time. It's not actually an issue, as I understand it, for the nuclear industry, it's more an issue for the medical profession -- surgeons and people who work with live X-ray images of patients, catheter tubes and things like that. I understand that that is where the pressure will come from particularly that their doses can exceed 20 millisieverts. So there will have to be more work done in terms of how that dose is measured, and how that is then controlled in the future. I think that work is ongoing at the moment.
Q. Just give us an idea. That I think you say is an example of where something moves a little faster than perhaps in other circumstances?
A. Yes.
Q. How long has it taken, just so the Tribunal get an idea, from the first paper suggesting that the present -- I'll call it a threshold -- I don't want that to be a loaded word -- but the present 150, I think you said, should be reduced to 20? How long has that taken as a process?

A. It's not formally a limit yet. It won't formally be a limit until it comes into legislation.
MR JUSTICE BLAKE: The safety standard?
A. The safety standards, yes.
MR TER HAAR: How long has it taken so far to get to the point where we haven't got a safety standard?
MR JUSTICE BLAKE: We have a safety standard but we haven't got legislation in force.
MR TER HAAR: Sorry.
A. A number of years. I am just trying to think if I can estimate that more closely without being misleading.
MR JUSTICE BLAKE: "A number of years" is an answer. You can't -- at the moment you are not sure.
A. I couldn't give you a precise number. It's a number of years, which I think will be smaller than 10. But I'm not sure about that. I would need to check on that.
MR TER HAAR: I'll come back to why I asked those questions a little later.
Can we go back to your CV then.
A. Yes.
Q. Don't get me wrong. In the area in which you've been operating I've absolutely no question that you know your stuff, right? I want to find out what the limits are on that.
So you left university, and took employment as

a safety adviser in 1976 and we see that three years.
You don't mention any specialist training.
Presumably you had some form of training in order to enable you to carry out your job as a safety adviser?
A. Yes, I did.
Q. Would that have been scientific training or would it have been practical: don't let people out without this suit on or those goggles on? What would be the nature of the training at that stage?
A. It would've been both those things.
Q. Just give us an idea.
A. I think particularly in the context you are asking the question, I attended two one-month training courses at what was then the National Radiological Protection Board, separated by about two years. So after I joined Sellafield, a short period after that I attended a one-month training course at the NRPB on health physics, and then I think a small number of years after that I attended another one, the advanced month training at the NRPB, again in health physics.
Q. The Tribunal may well know this, particularly the medical member, but what does health physics cover?
A. I think the simplest way to explain it is it's radiological safety. It's the -- it's -- it's -- well, just that: radiological safety. It is to understand the

principles of radiation protection and also to advise -- in my case advise plant managers on how they should control and minimise doses on their plants.
Q. And health physics appears to have been your special subject. Certainly it looks like promotion is going on: 1982 to 1986, health physics shift manager; 1986 to 1990, health physics area manager. And RPA? Radiological protection adviser would that be?
A. Yes, that's correct.
Q. This is presumably mainly internal, is it, to the various power plants that you were working with?
A. No. I mentioned a few minutes ago the ionising radiation regulations, 1999. The radiation protection adviser, the RPA, is a specific role identified in the ionising radiation regulations. It's someone who is appointed to advise the employer at Sellafield, in my case, on the implementation of the ionising radiation regulations.
Now, that -- do you want me to explain what the process is for that?
Q. Please do. If you can do it briefly but I would be grateful to learn.
A. Sure. It's a two-stage process. The first stage is that the applicant, me in this case, would put forward a portfolio, quite a lengthy portfolio, which would

describe both my technical training, so I mentioned the two courses, for example, that I described a few minutes ago, other technical training and there is effectively a list of topics which needs to be covered as part of that technical training.
The portfolio also needs to explain and identify your knowledge and experience in a number of other topics which are associated with the ionising radiation regulations. So ALARC would be one of them. What experience have you with ALARC? What is your knowledge? So papers that you've produced, any other documents that you've produced would go into the portfolio.
In my case the process was that would then go forward to -- the portfolio, which is quite substantial in my case, the portfolio would then go forward to an assessing body. I was actually also an assessor on that assessing body but I was also assessed by other people, clearly. And I was then interviewed by that assessing body. They'd already looked at my portfolio and then I was interviewed -- I can't remember, perhaps an hour or maybe longer -- interviewed by the assessing body, and they then made a judgment as to whether I'd reached the appropriate level of competence in terms of the technical requirements and knowledge of the ionising radiation regulations.

If you reach that stage, and it was found that I had reached that, you're then considered to be competent.
The second stage is you then have to be appointed by your employer to do a specific job because clearly the competence can be -- well, the competence is generic. But your ability to advise an employer specifically requires that you have additional knowledge and experience of the particular area where you are working. In my case that would be particular plants. In the medical profession because clearly, as I suspect you are familiar with, there are also medical RPAs and they would need to be appointed by a hospital to ensure that they had the appropriate experience and knowledge to be able to advise the hospital on specific areas -- X-rays, X-ray investigations, that kind of thing, and X-ray therapy, radiation therapy. It's a two-stage process.
Q. I think my question -- that's very helpful -- was not quite answered by your answer.
A. Right.
Q. What I was asking you was this. Your sphere of operation -- and we're still at the moment dealing with the period up to 1990 by which time you become a health physics area manager and an RPA -- your area of operation perhaps is one way of putting it was within the particular nuclear power plants that you were

concerned with?
A. My sorry?
Q. Was within the particular nuclear power plants --
A. My field of operation or my field of knowledge?
Q. Field of operation.
A. Field of operation, yes.
Q. Can I just ask so far as that's concerned, obviously the whole reason for your being there is that there are recognised dangers involved with a nuclear power plant?
A. Yes.
Q. Would I be right in thinking as a result of that the monitoring systems in every square inch of the nuclear power plant are very extensive indeed?
A. Yes, they are. Just one point of clarification, and sorry, I may be being pedantic here but just to be clear, although there were two operating power plants when I first joined Sellafield, Calder Hall was one of them and that continued to operate for a while and I did have some limited involvement in that, most of my operations were actually on the reprocessing point, just for clarity.
But yes, the point of your question is there would have been -- or there were, sorry -- installed equipment for various types of monitoring for sampling the air activity, monitoring the air activity, monitoring for

contamination and human monitors would regularly go round the different parts of the plant to assess the levels of radiation and contamination on those plants.
Q. Don't get me wrong. I'm sure that some cases go through the courts where people are criticising what has been measured and what hasn't. I'm not in that area. I'm just establishing the fact that clearly you have a potentially health-threatening industry, you are doing your best to keep the health risks to the minimum possible or reasonably practicable, and therefore part of that is to have very extensive monitoring so that you have a really accurate database of information. Would that be fair?
A. Yes. It was less so on the older plants which I first worked on. The newer plants which I worked on later that's -- yes, we had very extensive monitoring.
The earlier, the older plants which had been in operation for some time when I joined the site, yes, there was monitoring but it was not of the same level of sophistication.
Q. In a sense that answer anticipates -- obviously as health concerns in society grow and as technological advances occur, the standard of monitoring becomes more and more -- I'm not sure if the word "detailed" is the right word, but extensive?

A. Yes, and sophisticated.
Q. And sophisticated?
MR JUSTICE BLAKE: I also take it that the switch you mentioned to reprocessing was because Sellafield was moving from creating power into reprocessing spent fuel, was it?
A. Sellafield has always been a reprocessing site, my Lord, but there is also -- there were reactors on that site as well. The first reactors were there purely for military purposes. The later reactors were civilian reactors.
MR JUSTICE BLAKE: Right.
MR TER HAAR: Just moving from monitoring the atmosphere, the air, et cetera, was there also a programme of health monitoring of employees?
A. Yes.
Q. It may be that those also became more sophisticated but let's take it at when you first went into the industry in 1976. Would monitoring of employees already have been taking place at that time?
A. Yes. The principal monitoring, I'm just trying to think back now it's a long time ago, would have been by using what was called a film badge at the time. This was a blue badge that people may have seen, it's quite commonly photographed, which contains a small piece of effectively photographic emulsion, and you can assess

the level of radiation that's been received by the wearer from the patterns which are on the photographic emulsion when it is developed. I can expand on that if required. But that is a way of measuring the external radiation.
There was also some internal radiation monitoring. Initially that would -- well, perhaps rather than going to the detail, there was some internal monitoring but that became more sophisticated over the years.
Q. Well, let's just -- it may be easier to come forward in time and then go back.
A. Right.
Q. Would it now be standard practice, for example, to take urine samples and blood samples from employees?
A. Not blood samples.
Q. But urine samples?
A. Urine samples.
Q. And --
A. From people who were working on specific plants. The urine sampling would have been, from memory -- it is five or so years, five or six years perhaps now since I left the site, but the urine sampling for people would be focused principally on the plutonium plants, people working on plutonium plants, looking principally for plutonium in urine. I think there was also other urine

sampling going on, but actually I'm struggling a little bit to remember that now with any certainty.
Q. So there came a time -- again the exact date doesn't matter -- there came a time when it became standard practice to take urine samples from those who might be exposed to plutonium?
A. Yes.
Q. It I think follows from that answer that that's regarded as being the best indicator of internal contamination in a practical way. All right?
A. Yes, it is. It's not the only way. There were other forms of monitoring which were done. I mean I can explain what those were as well.
Q. If you can do it shortly. Certainly for my purposes I don't need a scientific exposition but just a broad guide as to what was going on.
A. There was a period when the new legislation was introduced when everyone who was working in what was known as a controlled area, the areas where the people were working on the processing plants wore small air samplers, called personal air samplers, which was a small sample paper which was positioned on the lapel close to the breathing zone. The air was drawn in through that and any particles of activity would be deposited on the filter card, filter paper, which would

then be counted. That is a very sensitive way of assessing the intake, rather than the uptake, to make that distinction. I can explain those two terms.
MR JUSTICE BLAKE: Could I just go back to urine just whilst we are on the topic.
A. Certainly.
MR JUSTICE BLAKE: One might think -- I might be wrong, you will tell me if I am -- that urine is comparatively a simple way of taking a sample?
A. It is. People are asked to -- without getting into the graphic details, they are asked to give -- I think it's a litre, a 1 litre sample, and they will fill a bottle over the space of a week or so and that will go for analysis.
MR JUSTICE BLAKE: How often do they do it?
A. Again it would depend on the nature of the work. I think from memory it would be done every quarter.
MR JUSTICE BLAKE: Right.
A. That's from memory.
MR JUSTICE BLAKE: But it doesn't require a doctor to take a blood sample?
A. No, no, the person fills up a sample bottle and that is then taken away for analysis.
If someone is thought to have -- if there is a risk that somebody may have received an exposure, an internal

exposure to plutonium they would also be asked to give urine samples. Actually they will also be asked to give faecal samples too, so that's another form of sampling but that's a specific investigation.
MR TER HAAR: And is there any form of continuing screening of people once they've left the employment of whichever company at that point in time owns -- British Nuclear Fuels or whoever it might be is the owner from time to time? Is there a continuing process of post-employment monitoring?
A. No. I think in the way that you mean that, no, there wouldn't be. So the sampling would be done by the employer. When the person leaves, and of course I have one of these, the individual's radiation dose that they have accumulated on the site is sent to them in a letter so that the individual will know what their accumulated dose has been. But there is no specific follow-up that I'm aware of.
There may be individual cases where that would be done in a special case but I'm not sure of that. That last point I think is an assumption or a speculation on my part. I couldn't say that with any certainty.
Q. Now going back to the question I was asking you about, the time it takes for a hypothesis to get all the way through to reflecting itself in legislation, which we

gather can be a period of years, I imagine that the monitoring regime of the nuclear industry that you were involved in will take into account changing scientific consensus about what you need to be watching out for, to put it in broad terms?
A. Yes.
Q. So if we take ourselves back to the 1950s, one of the things which I think you may be able to agree with me about is that if we look at the control regime as operated on Christmas Island for these various nuclear tests it wouldn't stand up for a second by modern standards, would it?
A. In terms of the monitoring procedures, the internal monitoring procedures, no, it would be -- it would be simpler. I think there was urine sampling going on in AWRE, I believe. I think there is reference to that made in some of the documents. Some of the monitoring controls that I've observed, particularly the control regimes around the balloon burst, the atomic weapons, so that's Grapple Z1 and Grapple Z4, I've looked at that. There is actually a film of that which is held by the Imperial War Museum which is available online and I've looked at their control regimes at the boundary of the -- again it's called the controlled area, the point where -- I think it's self-evident from the name -- at

one side you have no control, the other side you have controls. The boundary and the control at the boundary is clearly very important in terms of people being monitored with showering facilities and changing facilities.

The facilities that I've seen for Grapple Z1 and 4 were actually I thought quite impressive. The instrumentation looked very old, clearly, but in terms of the contamination monitoring, the surface contamination monitoring on the individuals I'm talking about, and on the vehicles I thought was done to a high standard from what I could see on that film.

Q. Well, I'll come back to that. But certainly so far as internal contamination is concerned, what you might think in today's terms of a perfectly standard process of taking urine samples simply doesn't appear to have been done for any of the soldiers that we are aware of?

A. No, I've seen no evidence of that whatsoever. I've looked for it and I'm pretty sure that that's the case.

Q. Standards change, of course, but by today's standards that would be an astonishing omission, wouldn't it?

A. Well, you would still need to assess whether people would need the urine sampling and you would still do an assessment based on whether somebody was likely to be exposed. Perhaps I could amplify that slightly, again

to explain how it would happen on a modern site because otherwise you tend to get into the catch 22-type situation of saying: how do you know if somebody needs to be monitored unless you're actually monitoring them?

The way you would do that on a modern site is you would run what are called campaigns, so that as part of the commissioning process and then every few years after that you would run campaigns either with personal air samplers which I described a few minutes ago, the little pump and the paper on the lapel, you might also do urine sampling. That would carry on for about a month, perhaps a little longer, to establish whether there was any indication of any significant dose whatsoever. If there was no significant dose, which is normally the case, then you would not introduce routine sampling but you would repeat that campaign a few years later.

So you would still make a judgment as to whether that kind of sampling was needed. I think where you're coming from is: was there any indication that any of that was done amongst the veterans on Christmas Island? And I don't believe it was. I think the assumption was simply that there was going to be no internal exposure and the monitoring was based on that.

Q. Well, rightly or wrongly -- we may get into debating whether it's right or wrong -- the whole process of

testing, the health testing of the veterans as they now are, the young men as they then were on Christmas Island, was based upon assumptions as to who would be affected and who wouldn't. That's a fair summary, isn't it?

A. Yes, I would perhaps say that it was based on judgments but nevertheless there were -- the number of people on a film badge issue was a relatively small proportion of the whole. I think the number of people on urine sampling -- I'm less certain about the urine sampling because it's just things I've picked up from passing references in documents. The amount of urine sampling going on was very limited and I think it was specific to the AWRE personnel.

Q. It was the boffins who got tested and not the conscripts?

A. I believe that that was still based on the judgment that they were more likely to be exposed because of the nature of their work. Particularly back in Aldermaston, of course they would have been involved in working with plutonium specifically, and therefore the level of risk of exposure would have been significantly higher and that would therefore inform the judgment as to whether urine sampling was needed.

Q. Now, I am going to spell out perhaps the blindingly

obvious. What we are concerned with today, the Tribunal is concerned with, are what the potential long-term effects may be of being in the vicinity of a nuclear test.

A. Yes.

Q. The first nuclear explosions are taking place in 1945, so taking the tests in 1958, there was at most 13 years' experience of what the effects might be?

A. Yes.

Q. So the Tribunal is obviously trying to grapple in part with that problem that this was a new form of human activity.

I don't think I've seen, but maybe you could correct me if I'm wrong, any detailed information about the effects upon those involved with the original Manhattan project in America. Have you seen any material to that effect?

A. No, I haven't.

Q. What appears to have happened is that we have the first two explosions, and within a year or two it was decided that this was an ideal sample that you could at least start carrying out research into what the effects of a nuclear explosion might be on the long-term health of people subjected to ionising radiation.

A. Sorry, you're talking about the inhabitants of Hiroshima

and Nagasaki?
Q. Yes, I am talking about what has been called in this Tribunal the LSS.
A. Yes.
Q. And of course what was being anticipated there was that there might be long-term effects of which people were unaware at that time?
A. Yes, yes.
Q. And indeed so it has proved although there's clearly argument about what those are.
A. Yes.
Q. It seems somewhat strange, given that there was going to be a programme of tests, first of all in Australia and then in the South Pacific, that so far as I can tell nobody at the time in the British Government said "Well, we ought to be carrying out a long-term survey to see what the effects of these tests are upon the people involved on behalf of Her Majesty's Government." Am I wrong in thinking that at the time no such steps were taken?
A. I don't think I can answer that. You mean in terms of: were there steps put in place in the late 1950s?
Q. Just to clarify my question, the question I am asking is this. Here we are, about to set off a whole series of increasingly large explosions.

A. Yes.
Q. We don't have much data on the long-term effects of such explosions upon people anywhere in the vicinity, whether it's going to be a mile away or 20 miles away, but we do have a sample here of several thousand young men who are going to be to a greater or lesser extent subjected to this. This will be an opportunity to add to our body of scientific information by monitoring them and seeing what happens.
Am I right in thinking that there doesn't appear to have been that sort of thinking in the '50s?
A. Amongst the bulk of the soldiers I think that's correct. I think amongst the bulk of the soldiers the assumption and belief and judgment was that the exposures would be small. There were one or two groups who were much more closely involved around the Ground Zero area -- I'm talking about Maralinga now in Australia. There were one or two groups who were associated who were involved with much higher levels of radiation, the indoctrinee force in Maralinga, and they would have received much more significant doses because they actually marched into the area and did some work around the Ground Zero in the vicinity of Ground Zero. Whether there's been any follow-up of those people I don't know.
MR JUSTICE BLAKE: I suspect you are being asked about

long-term studies or a baseline review or something, rather than simply: something has gone off, should we take a urine sample?
MR TER HAAR: That's exactly right, my Lord.
MR JUSTICE BLAKE: I have the --
A. I mean, I'm not aware of anything that was set up at the time, my Lord, but obviously there have been mortality studies which have been done since by Public Health England, by the Health Protection Agency I think at the time, the Muirfield studies, people like that, but they would be done retrospectively.
MR JUSTICE BLAKE: It is a retrospective analysis which really the delights of this case involves us in?
A. Yes.
MR JUSTICE BLAKE: I take it that your knowledge of these events, is that because you've been instructed by the Secretary of State as an expert or --
A. Yes.
MR JUSTICE BLAKE: -- did you have an interest in the history of radiological safety in the military context before?
A. No. Everything I've learned about that has been from the references, my Lord.
MR TER HAAR: I'm grateful. I am sort of using you in a way as a walking encyclopedia because you've done the

research, but I fully accept there's a limit on what you know that isn't already in the documents we have.
A. And I'm also trying to be precise if you like as well, perhaps more so than is necessary, but I'm trying to indicate as well if there's areas where I'm really not sure.
MR JUSTICE BLAKE: If you are not sure, please let us know.
A. Yes.
MR TER HAAR: That is exactly what the Tribunal would expect of you. So thank you.
Can we just look at the interplay between epidemiology and first of all your role as -- I'll call it broadly safety adviser. I know you have more specific roles.
We looked in the questions I was asking you earlier at the gestation time of how long it takes from a hypothesis -- my hypothetical Australian -- through to legislation and the steps in between.
One of the things which drives the setting of safety standards is obviously the results of epidemiological research.
A. Yes.
Q. That's absolutely fundamental to the whole of this issue.
A. Could -- yes, sorry, carry on.

Q. If we just take the process from hypothesis through to some specific measure being taken, it will tend to go through the process of saying: is this statistically significant; does this show us something we need to be worried about; if so, what do we do?
A. Yes.
Q. The same process can work backwards, can't it? If you are trying to work out what a dose level was at some point in the past, one way of doing it is to look at some health results suffered by a group of human beings -- let's assume a statistically relevant sample -- and say "If they suffered this consequence and if it was caused by radiation there must have been this level of dose at a site X years before". There are a number of factual points in the chain there but you can work backwards in that, can't you?
A. Sorry, could you just repeat the question? I think the answer is yes.
Q. I'll give you an example which was given by Professor Sawada last week and I think you were here when he gave his evidence.
A. I was here for some but not all.
Q. Right. Let's just take one of the examples that he gave. It has been assumed up to now that -- if I understand his hypothesis right -- 2 kilometres from

the hypocentre or epicentre of the Hiroshima explosion the risk of mortality from cancer was significantly less than within a kilometre of the epicentre and he says, well, if you look at the research done relatively recently by the Hiroshima University the levels of mortality at the 2-kilometre point are higher than if you like the background population of Japan but the same at 2 kilometres as at 1 kilometre.
For the moment I don't want to get into whether that's the right reading of the data but let's assume it is right.
So he says that must mean, if those deaths by cancer are caused by radiation, that the level of fallout at the 2-kilometre point must have been significantly higher than people have so far assumed. You were here when he was explaining that theory?
A. Yes, and I've seen his paper as well.
Q. Now there may be all sorts of methodological problems with his paper. I'm not asking at the moment whether he is right in that, but I use it as an example of how you can at least in theory work back from a medical consequence, a medical sequela, to what the dose level must have been at a particular time. You obviously have to work it out whether there are any other possible causes of that particular death rate, mortality rate,

but if you take those into account you can on occasion work back to get a dose rate retrospectively. Would you agree?
A. Yes, I think that's a reasonable proposition. I can't comment on Dr Sawada's paper. I have no expertise in Hiroshima. I've read his paper and I heard some of his --
MR JUSTICE BLAKE: I don't think you were being asked to. It was an example for the general proposition: can you sometimes work back from data to calculate dose?
A. Thank you, my Lord.
MR JUSTICE BLAKE: Or make some assumptions about dose?
A. I think it's reasonable to say the answer is yes.
MR TER HAAR: And the point I am making, perhaps rather laboriously, is that epidemiology can inform the reader of the papers both as to what the risks are going forward, but also, subject to suitable caveats and understanding of all the data, they may inform you looking backwards retrospectively as to what the dose rate must have been at a particular time?
A. As you say, subject to many caveats, yes. In principle, yes, it could be done.
Q. And the reason I ask you about this is this. If there was epidemiological evidence which powerfully suggested that the dose rates which you have assessed at

Christmas Island must be wrong by a significant margin, that would be something you would agree should be taken into account by the Tribunal in assessing the levels of dose which were so to speak available to be taken by each of the people on Christmas Island?
A. Yes, if there was -- again subject to the caveats in terms of the reliability of the effect that was observed, whether there were other factors that needed to be taken into account, confounding factors. We've heard quite a bit about chromosome aberration and I think there have been questions raised as to whether the chromosome aberration could be used to estimate dose retrospectively in the way that you are suggesting. I think it's been suggested that there are certainly doubts as to whether that is possible because of the other confounding issues, whether there are any other possible causes of chromosome aberration, whether it's practicable to do it over 50 years.
But in principle what you are describing, yes, I think that would be a factor.
Q. Now, as you I think understand, this Tribunal is engaged in what is a very unusual exercise of trying to identify whether there are reasonable doubts.
A. Yes, I understand that.
Q. And it will be my submission at the end of this hearing

that there's a credible body of scientific opinion which supports the view that the epidemiology casts considerable doubts upon the dose levels that you've assessed at Christmas Island. So before I go into that, can I just ask first of all have you in your assessment considered the epidemiological evidence from the Wahab and Rowland study?

A. I nearly said it I earlier but I thought I wouldn't. I have no expertise in epidemiology. I have read parts of papers or complete papers, in some cases, as part of my general education, general background knowledge, but I have no expertise in that area. Dr Haylock is an expert in epidemiology and I would suggest that if you have questions on the epidemiology that he would be the person to answer that.

Q. That's perfectly fair and that's what I anticipated. So this is not in any way a criticism, it's just establishing what you've done.

A. Yes.

Q. You have not yourself taken into account what the consequences or the implications might be of the Wahab and Rowland survey?

A. No, I've worked the other way. So I have started with a judgment as to what is the maximum likely levels of contamination that could exist on the island, and worked

forward from that to estimate the doses that I believe could have resulted from that.

Q. As I say, I'm not criticising that as a process. I'm just trying to establish what the process is.

A. I understand.

Q. Again I think I know the answer to this but sometimes I'm surprised by witnesses; you would not suggest that it would be an error for the Tribunal in deciding what happened to take into account not only your evidence but also the epidemiological evidence?

A. Oh not at all.

Q. I didn't think you were suggesting that.

A. Yes. Quite on the contrary.

Q. So just to follow it through, don't get me wrong, I understand that there are many debates about the Wahab and Rowland survey but if, just right at the extreme which isn't where the scientific evidence goes but just to test the proposition, if the Tribunal came to the view that they were absolutely certain that the Wahab and Rowland study was hard fact -- and I am not suggesting that's where it gets to, just to test the proposition -- and that was inconsistent with what you've worked out at considerable length with great care, you would accept that that would cast a doubt, if I can put it to that extreme, on the work you've done?

A. Yes, subject to all the caveats about the nature of the paper, whether it actually does indicate the doses, et cetera. But given the proposition that you've just put that if the Tribunal were to decide that they were satisfied with that evidence, then, yes, that would certainly be a factor to take into account in terms of then assessing whether my estimates were valid.

Q. I put it in that very extreme way because I don't want to lure you into territory which is not your territory of how reliable that evidence is, et cetera.

A. Quite, thank you.

Q. Can I just ask, if we go back to the beginning of your report, one of the reasons I had to ask you about that, there is an oddity. If you go to page 9 which is the start of your text and paragraph 1 starts:

"I am instructed by the Secretary of State for Defence to consider the evidence listed in appendix 2 to this report."

We've hunted for appendix 2 and haven't found it yet. It may just be it didn't get photocopied. Is there an appendix 2?

A. The appendix 2 -- we realised this last night -- the appendix 2 is the list of references.

Q. Right.

A. So it's all of the list of references and I should make

clear, if I could, to the Tribunal as well that some of these references are references that have been provided, some of these references are references that I have found. So it is a combination of what I referred to originally as appendix 2 and 3.

MR JUSTICE BLAKE: Can we just see where the references are?

A. I beg your pardon, this is on page 280 onwards.

MR JUSTICE BLAKE: 280 onwards.

A. And there are some references which I did take account of which are not listed here as an omission. I have taken account of all of the expert witness references produced by Mr Johnston and Professor Regan from the original First Tier Tribunal, so I've not specifically mentioned Professor Regan's expert witnesses but --

MR TER HAAR: What I am going to do in a moment, Mr Hallard, is I am going to actually take you to some of those, just to first of all identify whether you've taken them into account and secondly to see what's the interface between your expertise and theirs. So we'll get there as far as that is concerned.

MR JUSTICE BLAKE: Could I just clarify then that page 280 and following was meant to be your appendix 2, but you think, although this reference is to Johnson and Regan at 9, you've looked at for documents than you've actually recorded?

A. That's correct, my Lord.
MR JUSTICE BLAKE: We'd better find out before you complete your evidence what you actually looked at.
A. Would you like me to produce a list of the expert witness evidence?
MR JUSTICE BLAKE: We'll see how we go but that might be a good idea.
A. Right. It's all of the expert reports produced by Mr Johnson and Professor Regan for the original First Tier Tribunal.
MR JUSTICE BLAKE: Obviously we will have a great deal of fun looking at history and summaries and things but just in order to have confidence in the cross-referencing it might be helpful.
A. Yes.
MR TER HAAR: My Lord, I think this is a little bit over halfway through the afternoon if we are finishing at 3.30, if this would be a convenient moment? I am about to go to a different area, or we can carry on. Whatever suits the shorthand writers and the Tribunal.
MR JUSTICE BLAKE: Yes. Then we will take a break anyway for our purposes. Back at 3 o'clock and then we will have half an hour.
MR TER HAAR: Certainly, that's convenient.
MR JUSTICE BLAKE: So we are going to take a break to rest

the stenographers and for health and safety.
A. But I won't speak to anyone.
MR JUSTICE BLAKE: Please don't, thank you.
(2.45 pm)
(A short break)
(3.00 pm)
MR TER HAAR: As his Lordship has indicated, if you are more comfortable sitting at any point ...
A. I am fine.
Q. Could you take bundle SB11 which should be, I hope, in the rack behind you. (Pause).
It does look as though everybody's SB11 is perilously overfull. I think we might produce an S -- certainly the witness's SB11 looks thicker than everybody else's.
MR JUSTICE BLAKE: Mine just has tabs 8 to 9. Your tab has been growing overnight.
A. I start at tab 1 and go through to tab 10. SB11?
MR TER HAAR: SB11. You ought to have, I hope, 1, 2, 3, 4, all the way through to 10.
MR JUSTICE BLAKE: No.
MR TER HAAR: If you do not have that --
MR JUSTICE BLAKE: No. Up to 9.
MS MCCORD: 9, yes.
MR JUSTICE BLAKE: I think we are all up to 9.

MR TER HAAR: After that it's Dr Busby's reports and the originals so that's why they've been taken out.
MR JUSTICE BLAKE: Right.
MR TER HAAR: I still have them in my copy. We are not going to those, so yours is still perilously full as a file but I think the Tribunal's might not be quite so bad.
MR JUSTICE BLAKE: Yes. Why don't we take out tab 10?
MR TER HAAR: We'll do that when we've finished rather than do that now because I am not going to go them.
MR JUSTICE BLAKE: Right.
MR TER HAAR: Could we go to tab 1, first of all. Now, tab 1 is a report from Dr Brenner who is an American academic. He is specialist in radiobiology and radiation biophysics, I think. Would this be one of the reports you read?
A. No, I've never seen this before.
Q. On to tab 2. Tab 2 is the first of a number of reports from Professor Regan, and this, I think it's clear from your report and what you said earlier you have read.
A. Yes, I recognise this. It's quite some time since I read it.
Q. Could we just go to the second page of it and just look at his experience and see how this compares with your experience because I want to see, as I said earlier,

where you stop and others continue, begin?
A. Right.
Q. In the italics at the top of the second page he says this: born in Leicester in 1967; studied physics at the University of Liverpool, got a degree; a PhD in experimental nuclear structure of physics, University of York.
So certainly experimental nuclear structure of physics is a more advanced form of physics than you studied at Durham?
A. Yes, it is.
Q. And then:
"Research positions Nuclear Physics Laboratories, Pennsylvania, and Australian National University."
Then back lecturing physics at Surrey and you see a bit more and then if we go about a third of the way through do you see a sentence starting:
"He has co-authored more than 190 peer review publications."
Do you see that sentence about eight or nine lines down?
A. Yes, I do.
Q. "... peer reviewed publications in the field of experimental nuclear physics with particular focus on studies [the word "of" is missing] of the internal

structure of radioactive nuclear species using gamma ray decay spectroscopy."

Again a more advanced area of science than yours, I imagine?

A. Certainly.

Q. "... published a number of research articles on the measurement and characterisation of levels of radiation in the environment."

Now, measurement and characterisation of levels of radiation in the environment is certainly something which you've had to take into account as a safety adviser in the nuclear industry?

A. To a very limited degree. I would say that I have no expertise in environmental radiological protection. I have tried to make that clear in my report but just to be clear now, I do not have expertise in environmental radiological protection. It does tend -- it's a separate subject.

Q. And you are absolutely right, you've made that quite clear, for example at paragraph 20 of your report. You are very clear about that. But it seems to me there might be some overlap where we're talking about measurement and characterisation of levels of radiation, that certainly within the context of a nuclear power plant is an area which you would have to be involved in,

wouldn't you?

A. Yes.

Q. That's a very hesitant "yes".

A. I'm thinking about what he actually means by "characterisation" and I suspect what he means by that is to identify the particular nuclides in a sample of some sort. I've done a very limited amount of that, but very limited, and at quite a low level of expertise, just using an instrument called a gamma spectrometer, in fact, which can be used to identify gamma-emitting isotopes but not I think to this level of expertise that Professor Regan is describing.

Q. You can probably understand what he writes about but you wouldn't be the person who could write it?

A. I think that's probably true, certainly in terms of the expertise that he clearly has on different nuclear species and things like that, so I have some knowledge in that but he will have a great deal more.

Q. Can we go to the end of the italics, the last sentence:

"He has lectured at postgraduate level to MSc and PhD students on relevant areas including nuclear experimental techniques ..."

I am not entirely sure what that means.

"... nuclear physics, radiation dosimetry."

Is that something which you could claim equal

expertise with Professor Regan?

A. I'm not sure. Perhaps the easiest way to answer that is if I try to make clear where my level of expertise lies on that.

I have no expertise in the details of internal dosimetry and again hope I've made that clear in my report. So in terms of being able to identify the paths and the particular nature of dose that would be received by somebody following an intake of a radionuclide I don't have specific and detailed expertise in that area.

I am familiar with the use of the concept of what is called a dose coefficient. A dose coefficient is something that's published -- it's a series of numbers which are published by principally the ICRP. And the number itself is relatively simple. It says: for a given nuclide -- let's take plutonium-239 as one which I think people will have heard of -- if you receive an intake of 1 becquerel of plutonium-239 you will receive a dose of in this case, probably depending on the nature of the particle size, et cetera, 47 microsieverts.

MR JUSTICE BLAKE: So the coefficient is the exposure to dose --

A. Yes.

MR JUSTICE BLAKE: -- calculation.

A. Yes, and in the case I was just describing that's an inhalation coefficient. There are similar co-efficients for ingestion for gamma exposure, and I am familiar with use of those which is what a health physicist would normally use.

I have a broad outline knowledge of the basics of ICRP internal dosimetry modelling, simply because I don't like using numbers as a black box, so that: here is a number, do you have any understanding of it? So I have an outline understanding of it to make sure that I'm using it as intended but I don't have a detailed understanding of the modelling and how you would derive those numbers.

MR TER HAAR: Just to put a bit of colour on this it was Professor Regan -- you may know this -- who identified what happened to Mr Litvinenko.

A. Was it?

Q. That he had almost certainly been fed an alpha-emitter. Perhaps you didn't know that.

A. I didn't know that. I knew it had been established very late in his life within only a few days of his death but I didn't know it was Professor Regan who did that.

Q. Whether that is right or not, that's the sort of advanced specialisation he has which you don't have?

A. Yes, I mean I would -- I am familiar with the concept again of urine sampling but in that context I would be requesting a urine sample and I would be requesting that that be sent off for analysis. Perhaps Professor Regan got more deeply involved in the process of analysing and discovering that it was polonium that was the source.
Q. My impression from your report, and I think I'm correct in this, is that what you have done is taken Professor Regan's reports -- and you also gave oral evidence, I think -- you have certainly taken his report and fed that into your process of reasoning and analysis?
A. That's certainly my intention, yes.
Q. And --
A. And the same thing for Mr Johnston. I have read the transcripts as well, although there's a great deal of information there.
Q. And I think there is no area in which you suggest that Professor Regan has got it wrong and you've just taken his material as being accurate. Is that a fair summary?
A. In terms of his description of nuclear physics and health physics, is that what you mean?
Q. I think in any of the conclusions he comes to.
A. I can't think of a conclusion off the top of my head where I've strongly disagreed with him. I think perhaps

there are one or two areas where he has indicated qualitatively that a dose may be larger than the dose which I've quantified but in terms of the principles of it, no, I think from memory -- as I say, it's quite a while since I've read these but from memory I don't think so.
Q. Certainly where he has come to a higher qualitative assessment than you have, whilst you might differ you would accept that he's the person with appropriate expertise whose views are legitimate alternative views to yours?
A. Yes, I think that's -- yes, yes, I think I would agree with that. I hope that in my report -- and I've certainly sought in my report to break down and explain in as transparent a way as possible where my estimates of dose have come from, and from memory I don't think Professor Regan has done that. There may be one or two cases but I can't actually remember that being done in that way. But forgive me if I'm wrong about that.
Q. I think it's fair to say that he's perhaps dealing with things generally on a slight broader brush basis than you have.
A. Yes, I think that's true.
Q. So broadly you find nothing to criticise in his report from your standpoint. If there were differences -- and

we'll look in detail -- you'd accept that he hasn't in any way stepped outside his appropriate field, it's just different experts can differ about matters?
A. Yes, I've certainly not noticed any area where he appears to have stepped outside of his field.
Q. Thank you.
Then, again this may be helpful for the Tribunal just to see what we have, if you go to tab 3 there's a short, two-page report by Professor Regan dated 5 October 2010 and I take it that you have also looked at it and taken that into account?
A. Yes. If I remember this report correctly it basically looked at the calibration of the film badges which were used in Christmas Island, and if I remember the conclusions I think he concluded that they were reasonable.
Q. Yes. Well, we can look at it in detail but he had some qualifications about what had been done. There's nothing in that report that you would like to give a health warning to the Tribunal about?
A. Nothing that I can remember, no.
Q. On to tab 4. I think this is probably where you wouldn't have got yourself involved but maybe you did. Professor Parker is an epidemiologist.
A. I've not seen this report.

Q. No, nor would I expect you to given what you've said.
So tab 5A, 5B, it's more of her evidence. Tab 6?
MR JUSTICE BLAKE: So that's likewise. Parker, outside?
A. Yes, I've not seen these reports. I don't recognise of these.
MR TER HAAR: That's entirely understandable.
Tab 7 ...
MR JUSTICE BLAKE: 5A, 6.
MR TER HAAR: That's up to 5 and 6.
At 7 we get to Dr Mothersill. She's a radio-biologist and I imagine again this would not be part of your world, so to speak?
A. Again, I don't recognise this report.
Q. Then the last one in this bundle, Professor Sawada, tab 9. You may or may not have seen it but it doesn't really impinge on what you were asked to advise about at all, does it?
A. Tab 9?
Q. Tab 9, yes.
A. Right.
MR JUSTICE BLAKE: This is an article.
MR TER HAAR: Its an article.
A. Again, I don't recognise it. I don't believe that I've seen it.
Q. Then your bundle may contain a number of reports from

Professor Busby, but they've been taken from the Tribunal's bundle so don't go to those.
A. Okay.
Q. Could you put that bundle aside, please, and go to bundle 12. I am just doing the same exercise of trying to identify what you've seen. So bundle SB12, please.
The first divider contains quite a wide selection of material but I can't believe there's anything here you would have looked at. It's all to do very much with medical conditions rather than --
A. This is from tab 11 onwards; is that correct?
Q. Tab 11 is the first one. Just skim read it. I would be very surprised if you were given any of the material in 11.
A. No.
Q. 12 and 13 are reports from Mr Large. Now it's possible you might have been given these because --
A. I have seen one report from -- is it Professor Large? John Large anyway.
Q. Mr Large.
A. Okay.
Q. So you may have looked at one or other of these?
A. From memory I've looked at one of his. Whether this is the one, I would need to look at this again to be sure that this was the one.

Q. Right.
A. The one that I read was principally about the height of the detonation of the --
MR JUSTICE BLAKE: That's that one, isn't it?
MR TER HAAR: That is Dr Nicholson. That's likely to be, although there is part of this that deals with this. If you go to page 3, yes, page 3 of tab 12, we have some data as to the height of the Grapple Y detonation there.
MR JUSTICE BLAKE: Is that the one you were referring to?
A. It could be. It's been a long time since I looked at them, my Lord.
MR JUSTICE BLAKE: You are going to provide anyway this supplementary appendix 2 which might make it clearer.
A. Yes.
MR JUSTICE BLAKE: Right.
MR TER HAAR: Now, my recollection is that you don't comment in your report about either of the two Mr Large statements at 12 and 13. I assume that's right, first of all, is that your recollection as well?
A. It is my recollection. Particularly the areas of the height of detonation, I didn't feel that I had any expertise to be able to comment on that.
Q. But there is an overlap between what he comments on and your report. Take, for example, the second page of this. He's commenting on what he describes as certain

Government annexes show, which appear to deal with questions of amounts of external radiation dose receipt, as he calls it, and radiation data.
So I just wonder why did you not comment upon this material?
A. Sorry, we are on page 2?
Q. I was just looking at page 2. If you just cast your eye down it --
MR JUSTICE BLAKE: This is Large second statement, tab 13.
MR TER HAAR: Yes, I'm sorry.
MR JUSTICE BLAKE: Page 2, the paragraph numbering is a little faint.
MR TER HAAR: Yes, I think --
MR JUSTICE BLAKE: "My review"?
MR TER HAAR: Yes. I think it must be paragraph 12 originally, but (i) to (iii) and then 1, 2, 3.
MR JUSTICE BLAKE: So it's what we think is paragraph 12, is that what you are asking this witness about?
MR TER HAAR: Yes.
MR JUSTICE BLAKE: Yes.
A. I'm not sure if this is the same report that I've read.
Q. That explains why you didn't comment on it.
A. Yes. I'll have to admit to a vulnerability on this that it is so long -- it's perhaps a year since I've read some of these reports. That's when I first started

working on this. I don't have a number of these reports electronically either, so it would be difficult for me to confirm whether this is the report. From a quick skim read it does not look familiar. Was there a second report from John Large?
Q. There were two reports from him. The first report is tab 12 and then the second report, which he calls a statement, at tab 13.
A. Ah, I can't be sure. I would need to go through it in more detail, but I have a feeling that this is the report that I've seen.
Q. By "this" you're referring to tab 12?
A. Tab 12. Please don't take that as a definitive statement, I would need to go through it again, but I believe from a quick look that that certainly looks more familiar than the paper in tab 13.
Q. All right.
MR JUSTICE BLAKE: Would you like this witness to refresh his memory by Monday about this paper, or it's not a topic you are going to pursue with him?
MR TER HAAR: I'm not going to pursue it at any great length. I'm most interested in the ones that Mr Hallard has looked at --
MR JUSTICE BLAKE: Yes.
MR TER HAAR: -- rather than those he hasn't.

MR JUSTICE BLAKE: This is an ambiguous category.
MR TER HAAR: Divider 14, another report from Professor Regan.
This probably is something that I think you would have looked at. Because, for example, at page 7 he's got a section headed, "Additional notes on radiation measurement and detection", and perhaps of significance, it's a matter for the Tribunal, at paragraph 55 at the bottom of that page he comments that personal dosimeters don't give any measurement for internal ingestion or inhalation of radiation.
A. Sorry, which tab is this?
Q. Sorry, tab 14, and I was taking you to page 7. I'm sorry if I am mumbling a bit. I am pointing out that halfway down the page --
A. Sorry, forgive me, which paragraph number are you looking at?
Q. First of all, get the cross heading, "Additional notes on radiation measurement and detection". Then 55 is where I was taking you to.
MR JUSTICE BLAKE: It looks like you are getting lost. What's your tab 14, please?
A. It is Maralinga report by Professor PH Regan.
MR TER HAAR: No wonder! There should be a 14, headed on the first page "Supplementary report by PH Regan".

MR JUSTICE BLAKE: You are at our 14B.
MR TER HAAR: It looks as though we have a bundling problem. Let's pass over that. We can make sure everybody's bundles are the same by Monday, otherwise we'll get very lost.
MR JUSTICE BLAKE: Yes, all right, it looks like your bundle is defective.
DR BUSBY: We have the same --
MR TER HAAR: We will make sure everybody --
MR JUSTICE BLAKE: That is a conversation between you over there. But anyway --
MR TER HAAR: The only thing I would ask, just while we are on this as a matter of practicality, if you are not dying to have the bundle yourself over the weekend if we could have access to SB12 --
MR JUSTICE BLAKE: You are not going to have access to our bundles now. I am going to bring the shutter down on that, because we are starting to note up things and I am going to say things about that at the end.
MR TER HAAR: We will have to liaise with the clerk.
MR JUSTICE BLAKE: Do it through the clerk.
MR TER HAAR: We just need to find the machinery. Anyway, let's carry on.
A. I am sorry, did you say paragraph 55 says "with regard to the use of sticky paper"?

MR TER HAAR: No, I moved on. No, paragraph 55 at page 7 starts with the words "Personal dosimeters" in the version I have.
A. I thought I'd found the paper.
MR JUSTICE BLAKE: That's another report.
A. Right.
MR JUSTICE BLAKE: Where is that one you've just found? What is that called in your bundle? Does it have a tab number?
A. It's still under tab 14.
MR JUSTICE BLAKE: Right. Tab 14 has now been divided into three.
A. Ah.
MR JUSTICE BLAKE: What you've just been referring to is our tab 14A, if this is of help to anybody who is discovering the archaeology of the bundles. We are all on the same. We have 14, 14A and 14B, and we have the master indexes, so one can compare what we have with what we should have. If there are going to be additions to our bundles through the clerk --
MR TER HAAR: We will take it that what the Tribunal has is the master copy from which the rest of us will --
MR JUSTICE BLAKE: Otherwise we will need a Japanese interpreter.
MR TER HAAR: Yes.

Mr Hallard, if you go on, please, to tab 15. That, I hope, has at the top of it the the names Guy Higginson and Nick Crossley, or are we beginning to lose each other again? Tab 15.
A. I have under tab 15, final report by Dr Thomas Lindahl --
MR JUSTICE BLAKE: Okay. This bundle is in a hopeless state.
MR TER HAAR: It really is.
MR JUSTICE BLAKE: Stop, there's no point going on.
MR TER HAAR: I am wasting the Tribunal's time.
Let's see whether --
MR JUSTICE BLAKE: Can someone hand -- well, I think someone from your team if they have the time and the patience should go through the witness' bundle to make sure it's in good order.
MR TER HAAR: I always like giving work to other people. It will be done.
MR JUSTICE BLAKE: Thank you, yes. If you negotiate with our clerk about locking up times of the courtroom, you may be allowed out at the weekend.
MR TER HAAR: And I see the time. So rather than have another exercise with the next bundle let's make sure we're all online together.
MR JUSTICE BLAKE: Please, let's do that. I think we are

obviously hitting some technical problems on our side here so I think we will interrupt your evidence.
A. Yes, my Lord.
MR JUSTICE BLAKE: We will meet again on Monday. 10.30 Monday?
MR TER HAAR: That's fine by me.
MR HEPPINSTALL: Dr Haylock is here but he was hoping that he could be released and he doesn't have to be here on Monday and will return on Tuesday.
MR JUSTICE BLAKE: I think you are going to be --
MR TER HAAR: If we get to Dr Haylock on Monday we will have shaved so much time off this hearing that we'll all want to go to the bar and have a glass of champagne.
MR JUSTICE BLAKE: Depending on what is happening in France.
MR TER HAAR: Putting it seriously, we are unlikely to get to him and if we do we will be well ahead of timetable.
MR JUSTICE BLAKE: We can release Dr Haylock until Tuesday.
MR TER HAAR: Absolutely.
MR JUSTICE BLAKE: At some point at the end of Monday we might review, 10, 10.30, but for Monday 10.30.
MR TER HAAR: Please.
MR JUSTICE BLAKE: So I have some other things to raise with you but we can let the witness go home. Thank you very much --
A. Thank you, my Lord.

MR JUSTICE BLAKE: -- for today. We will continue with your evidence where I think the estimates are you'll be most or all of Monday.
A. Yes, my Lord.
MR JUSTICE BLAKE: We'll continue at 10.30, then I hope we'll complete your evidence by Monday afternoon.
A. Thank you, my Lord.
MR TER HAAR: I think that might -- the estimate was three and a half days, which may be too long but finishing by Monday afternoon is likely to be --
MR JUSTICE BLAKE: I misunderstood. Yes, we'll certainly be with you on Monday and possibly Tuesday.
A. Okay.
MR TER HAAR: I think that's more realistic, I'm afraid.
MR JUSTICE BLAKE: Yes, very good. There was nothing else you wanted him to read over the weekend to refresh his memory in order to avoid further delays?
MR TER HAAR: We must obviously sort out the bundles but nothing for Mr Hallard.
MR JUSTICE BLAKE: It would probably be helpful if he did have a complete list of what you actually have read available, just to cut that process down. Thank you.
(The witness withdrew)
Housekeeping
MR JUSTICE BLAKE: So did anybody else have issues of

management for next week to raise with me? No, right.
Sorry, I just have to make sense of my notes.
Yes, one issue: when we looked at the report behind the formal article about New Zealand -- the Wahab results -- Dr Rayner made reference in the questions she posed to Professor Thomas about an article on Polynesian radiation rates. Do you know what I'm talking about?
MR HEPPINSTALL: I remember the --
MR JUSTICE BLAKE: It's a reference cited --
DR RAYNER: Violet.
MR JUSTICE BLAKE: Thyroid cancers amongst the Polynesian community. I don't know, is that a paper that is somewhere to be found for the curious observer in our other papers or is that outside?
MR HEPPINSTALL: No.
MR JUSTICE BLAKE: Just in order to track down any reference which has emerged, might it be an idea if it was available so you can at least consider whether it has relevance to any of the issues?
MR HEPPINSTALL: We can certainly do that for you.
MR JUSTICE BLAKE: Thank you. It's best to do it that way round.
Two, we did I think borrow and get a screen in case we needed a slide show for any part of the cross-examination of Professor Sawada. I think we've

managed to do without it. Are we likely to need that for next week?
MR TER HAAR: Not as far as I'm concerned. I don't know whether Professor Busby thinks we do.
DR BUSBY: My Lord, I'm told that we want to project some of these photographs onto it because the quality of the photographs that were provided --
MR JUSTICE BLAKE: So you might need it for next week. All right, we'll keep it on. I just don't know whether I've got to give it back to someone else at some stage.
Right, I haven't had a chance to read those e-mails that you handed up and I don't want to say anything more about it, but I think we're all very sorry that the witness who has received these should have received things which are alarming and intimidating, and as far as I'm concerned if you could pass on my regret that that's happened to Professor Thomas I would be grateful.
MR HEPPINSTALL: We will, my Lord.
MR JUSTICE BLAKE: Thank you.
Right, well, then have a good weekend and see you Monday at 10.30.
(3.35 pm)
(The court adjourned until Monday 20 June 2016 at 10.30 am)
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